Science

Proposed Appropriation Language

For expenses of the Department of Energy activities including the purchase, construction and acquisition of plant and capital equipment and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion, and purchase of not to exceed [5] *6* passenger motor vehicles for replacement only, [$2,682,860,000] *$2,835,393,000*, to remain available until expended[: *Provided*, That $7,600,000 of the unobligated balances originally available for Superconducting Super Collider termination activities shall be made available for other activities under this heading]. *(Energy and Water Development Appropriations Act, 1999.)*

[An additional amount of $15,000,000, to remain available until expended, for Department of Energy—Energy Programs, "Science", is hereby appropriated.] *(Omnibus Consolidated and Emergency Supplemental Appropriations Act, 1999, Public Law 105-277, Division A, Section 109.)*

Office of Science

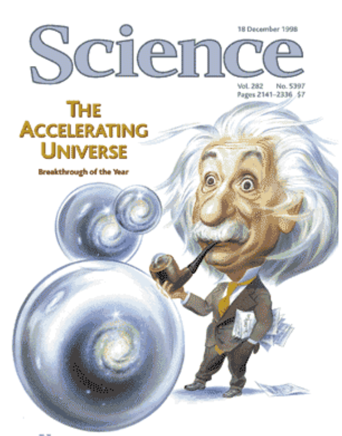
Executive Budget Summary

The Office of Science (SC) requests $2,844 Million for Fiscal Year 2000, an increase of $138M over FY 1999, to invest in thousands of individual research projects at hundreds of research facilities across the U.S., primarily in our national laboratories and research universities. The FY 2000 request will allow for continued construction of the Spallation Neutron Source, the first world class neutron source built by the U.S. in over 30 years; a new Scientific Simulation Initiative that will revolutionize our ability to solve scientific problems of extraordinary complexity and enable us to apply these new resources toward advancing DOE missions; participation in the Next Generation Internet effort with a focus on R&D and implementation of the technologies and tools that help meet mission requirements and contribute to the Scientific Simulation Initiative.

A History of Success:

Past successes from the SC research program and scientific user facilities have produced a rich history of contributions to science and society.

- Supported the work of 66 Nobel Laureates, from Enrico Fermi and E.O. Lawrence to Richard Smalley and Paul Boyer.
- SC's High Energy Physics program Supported *Science Magazine's* "1998 Breakthrough of the Year - *The Accelerating Universe*"



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- Developed the original prototype for positron emission tomography (PET) and the most widely used radio-pharmaceuticals used in nuclear medicine, provided the knowledge base for the nation's, and world's, radiation exposure standards, established the first Human Genome Program and the first global climate change research program.
- Advanced our understanding of the subatomic world and the fundamental forces and particles of nature through forefront research and research facilities, including the world's first super-conducting accelerator. These facilities offer a window into the most elusive particles and interactions at the very heart of matter illuminating the origin of the universe.
- Building on the advances of accelerator physics, synchrotron light sources were first conceived, constructed and utilized by SC scientists for research that enabled the discovery of new materials, advanced chip technologies, and breakthroughs in structural biology.
- Provided the first scientific investigation of multi-megawatts of fusion power produced in laboratory plasmas.

A Notable Change:

During FY 1999 budget deliberations, in recognition of more than 50 years of contributions to science and basic research, Congress changed the name of the Office of Energy Research to the Office of Science. With the FY 2000 budget request, we begin a new era as the Office of Science and, looking ahead to the challenges and opportunities of the twenty-first century, we are building a new SC strategic plan for the future research needs of the Department.

Our Mission Hasn't Changed:

Our mission remains to: produce the scientific and technical knowledge needed to develop energy technology options; understand the health and environmental implications of energy production and use; maintain U.S. leadership in understanding the fundamental nature of energy and matter; provide and operate the large-scale facilities required in the natural sciences; ensure U.S. leadership in the search for scientific knowledge; and support the availability of scientific talent for the next generation.

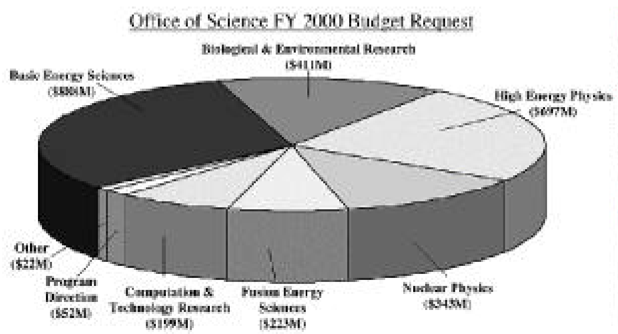

Figure 1

The FY 2000 budget request, depicted in Figure 1 and Table 1, has a program structure, that meets our mission consistent with Department goals and strategies. The major programs of the Office of Science are: High Energy and Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Computational and Technology Research, and Fusion Energy Sciences.

The Department of Energy is a science agency because its mission and goals require technologies and scientific knowledge far beyond that which is currently available. From safeguarding the nuclear stockpile to ensuring our nation's energy supply for the next century, DOE continues to challenge the frontiers of science and technology.

The DOE Strategic Plan outlines the vision, goals and strategic objectives that will, through leadership in science and technology, help the DOE to meet those challenges. In keeping with the Government Performance and Results Act (GPRA), the Office of Science FY 2000 budget request includes program specific goals, strategies, and measures that focus our research activities and ensure continuity with Departmental plans and national goals.

Rethinking Our Goals and Strategies:

In the past year, the Department has begun to characterize the whole of our R&D efforts across business lines. The purpose and scope of this effort are to extend the work of the new SC strategic plan in terms of the R&D investments that enable us to meet our objectives and goals, and to assemble key information for improving our analysis and management of these investments.

The Office of Science's basic research supports and enables the R&D of the other business lines. A Science Portfolio has been developed with this fact in mind so as to clarify and improve integration of our program results throughout the Department. This Portfolio accompanies the release of the FY 2000 budget request.

As the Department builds R&D portfolios for its other business lines, the Office of Science will continue to integrate basic research with the applied R&D in the other business lines' portfolios so that there are strong linkages between technology needs and science.

The revised Strategic Plan of the Office of Science, to be published in Spring 1999, will articulate the long-range vision, goals, strategies, and objectives for our programs. The Science Portfolio complements and supports the strategic plan by providing a near-term "snapshot" of our investments against the new strategic framework.

The motivations behind this planning effort are to develop a shared long-term focus for SC programs, their scientific communities and performers; to position our future scientific program content to better serve the other DOE business lines and provide a framework for cooperation and risk taking; to project future possibilities and directions for our programs based on the latest technologies and scientific advances; to better illustrate the unique and coordinated role of SC programs within the DOE mission and the federal science investment; to inspire our researchers and to better communicate our program content and successes to our sponsors and the general public.

The new SC strategic plan, and supporting Science Portfolio, is structured around five high-level goals with twelve strategic objectives, listed in Figure 2. These goals were developed through a series of planning activities and workshops that drew on the experience and knowledge of our research scientists and stakeholders to capture both what is necessary and what is possible for our science as we look to the next century.

The first goal, **Fueling the Future**, is centered on science for affordable and clean energy options for the future. Some of the questions that motivate this goal are: *How can we tap and harness affordable, clean fuels? What clean new electric power systems will fuel the future?* and *How can energy systems be made more efficient and environmentally sound?* Development of this goal has been closely connected with the development of the Energy R&D portfolio and the objectives directly map onto the energy portfolio.

The second goal, **Protecting our Living Planet**, is centered on understanding energy impacts on people and the biosphere. Some of the questions that motivate this theme are: *What are the sources and fate of energy-related by-products? What factors affect global climate and how can they be controlled?* and *How do complex biological and environmental systems respond to our energy use?* This goal also contributes to both the Energy R&D portfolio and the Environmental R&D portfolio.

- **Fueling the Future**
  - **New Fuels**
  - **Clean and Affordable Power**
  - **Efficient Energy Use**
- **Protecting Our Living Planet**
  - **Sources and Fate of Energy By-Products**
  - **Impacts on People and the Environment**
  - **Prevention and Protection**
- **Exploring Energy and Matter**
  - **Components of Matter**
  - **Origin and Fate of the Universe**
  - **Complex Systems**
- **Extraordinary Tools for Extraordinary Science**
  - **Instrumentation for the Frontiers of Science**
  - **Scientific Simulation**
  - **Institutional Capacity**
- **Enabling World Class Science**

Figure 2

The third goal, **Exploring Energy and Matter**, is centered on discovering the building blocks of atoms and life. Some of the questions that motivate this theme are: *What are the fundamental components of matter? How can the origin and fate of the Universe reveal the secrets of energy, matter and life?* and *How do atoms and molecules combine to form complex dynamic systems?* This goal captures the most fundamental research in the Office of Science. The complex systems question links to R&D efforts in all of the DOE business lines.

The fourth goal, **Extraordinary Tools for Extraordinary Science**, is centered on the national assets that DOE provides for forefront, multidisciplinary research. This goal builds on the unique role of the Office of Science in providing the nation with forefront research facilities such as the National Laboratories, and an array of research accelerators, reactors and other unique facilities. The Office of Science will continue to ensure that these critical research tools remain accessible to peer reviewed researchers from all across the nation and meet the technical challenges of forefront scientific investigation. This goal looks to the future and to training and educating the next generation of scientists and engineers.

Some of the questions that motivate this goal are: *How can we explore the frontiers of the natural sciences? How can we predict the behavior of complex systems?* and *How can we strengthen the nation's capacity for multidisciplinary science?* This goal enables research in all of the DOE business lines. By organizing future facilities needs, as identified by the scientific community, this theme ensures that America's research capability will remain both accessible and state of the art.

The fifth goal, **Enabling World Class Science**, conveys the commitment of DOE and National Laboratory staff to continuously improve their operational processes. Of paramount importance is the selection and conduct of excellent, productive science that is carried out safely and with care for the environment and involvement of local communities.

Implementing the New Strategies - Initiatives for FY 2000:

These five goals provide a framework for current programs and a platform for future efforts. FY 2000 initiatives and priorities are detailed below. Figure 3 lists these initiatives and identifies linkages to the SC goals.

	Fuel the Future	Protect Our Living Planet	Explore Energy & Matter	Extraordinary Tools for Extraordinary Science
Scientific Simulation Initiative	✓	✓	✓	✓
Spallation Neutron Source	✓			✓
Large Hadron Collider			✓	✓
Scientific User Facilities	✓	✓	✓	✓
Next Generation Internet				✓
Climate Change Technology Initiative	✓	✓		
Genome	✓	✓	✓	✓

Figure 3

Scientific Simulation Initiative - It is now possible to obtain computational capabilities 100 times faster than currently in common use through the application of technologies developed for the Accelerated Strategic Computing Initiative (ASCI). Therefore the Department of Energy, in coordination with the National Science Foundation and other federal science programs, has developed a Scientific Simulation Initiative (SSI) in support of the President's Information Technology Initiative. The mission of the SSI is to further develop and employ the emerging generation of very high performance computers as major tools for scientific inquiry. These resources will revolutionize our approach to solving complex problems in *energy, environment, and fundamental research* and will stimulate our national system of innovation.

Portions of the program will be directed by a joint SC/Defense Programs ASCI research management committee. Within the Office of Science, the SSI will be an integrated effort with the Computational and Technology Research (CTR) program coordinating and overseeing competitive, peer reviewed selections of sites and applications. CTR, with Basic Energy Sciences (BES) and Biological and Environmental Research (BER), will manage the basic research applications.

Combustion - Currently, eighty-five percent of U.S. energy use is derived from the combustion of fossil fuels and this dependence on combustion is not likely to change in the coming decades. Combustion remains one of the primary causes of lowered air quality in urban environments. At present, engineers have neither sufficient knowledge nor the computational tools to understand and predict the chemical outcome of combustion processes with any degree of practical reliability. Existing models that guide the design process are of very limited usefulness because of the extraordinary complexity of the combustion process. With very high end computing resources and a concerted research program in combustion modeling, we can develop the next generation of combustion modeling tools for accelerated design of combustion devices meeting national goals of emission reduction and energy conservation.

Global Systems -Unlike many disciplinary areas of research, the complex workings of the global environmental system cannot be studied in a laboratory setting. The integration of knowledge from the many disciplines that together describe the global system can only be performed in computer simulation models. It is only through such general circulation models that it is possible to understand current climate and climate variability and to predict future climate and climate variability, including prediction of the possible effects of human activities on the global system. Advances in scientific understanding are therefore predicated upon the successful development of modeling tools to keep pace with the rapid advances in the quality and quantity of data available. These tools will lead to the development of detailed fully coupled global system models that accurately reproduce, and ultimately predict, the behavior of the interacting components of the system, i.e. the global atmosphere, the world ocean, the terrestrial land surface and both glacial and sea ice.

Fundamental Research - Whereas the scientific accomplishments of this century have resulted in seeking and understanding the fundamental laws that govern our physical universe, the science of the coming century will be characterized by synthesis of this knowledge into predictive capabilities for understanding and solving a wide range of scientific problems, many with practical consequences. In this endeavor, the computer will be a primary instrument of scientific discovery. Many areas of scientific inquiry, critical to the department's mission, will be advanced dramatically with access to high-end computation - including, but not limited to, materials sciences, structural genomics, high energy and nuclear physics, subsurface flow, and fusion energy research.

The **Spallation Neutron Source** (SNS) - The importance of neutron science for fundamental discoveries and technological development has been enumerated in all of the major materials science studies over the past two decades, including a major study by the National Research Council entitled "Major Facilities for Materials Research and Related Disciplines" (Seitz-Eastman Report)

As the needs of our high-technology society have changed, so has the way in which we conduct the R&D that helps us to meet those needs. It has become increasingly important to develop new materials that perform under severe conditions and yet are stronger, lighter, and cheaper. Major research facilities are used to understand and "engineer" materials at the atomic level so that they have improved macroscopic properties and perform better in new, demanding applications.

The SNS is a next-generation facility for these types of applications. Neutron scattering will play a major role in all forms of materials design and understanding. This research will lead to the development of advances such as: smaller and faster electronic devices; lightweight alloys, plastics and polymers for transportation and other applications; magnetic materials for more efficient motors and for improved magnetic storage capacity; improved understanding of form and function in biological structures and the development of new drugs for medical care.

Upon completion, the SNS will be the world's most powerful neutron source, accommodating more than 1,000 researchers and 30 to 40 special purpose instruments.

The SNS Total Project Cost (TPC) is estimated to be $1,360 million over a 7.25-year schedule. The original TPC of $1,333 million (7-year schedule) was independently validated to within 1%. Throughout the life of the project, semi-annual reviews will track cost and management. FY 1999 funding provided for the start of Title I design activities, initiation of subcontracts and long-lead procurement, and continued R&D to reduce technical and schedule risks. FY 2000 funding of $214M will support Title II (detailed) design for the technical components and control systems. Construction will begin in FY 2000 on some of the conventional facilities as will the procurement of key technical equipment.

The SNS project is an example of DOE's commitment to use the DOE laboratories as a system. Under DOE leadership, Oak Ridge National Laboratory is responsible for the project with participation from Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Brookhaven National Laboratory, and Argonne National Laboratory. The laboratories have been working together most effectively and R&D is proceeding smoothly.

Scientific Facilities Utilization - This FY 2000 budget request continues to strongly support Scientific Facilities Utilization in the following programs: Basic Energy Sciences, High Energy Physics, Nuclear Physics, Fusion Energy Sciences, Biological and Environmental Research, and Computational and Technology Research. Each year, over 15,000 university, industry, and government sponsored scientists conduct cutting edge experiments at these particle accelerators, high-flux neutron sources, synchrotron radiation light sources, and other specialized facilities, such as the Combustion Research Facility (CRF) at Sandia National Laboratories, Livermore, California. The CRF is an internationally recognized facility for the study of combustion science and technology, which will begin its first year of operation after its Phase II development project.

The user community continues to be pleased with the results of the Science Facilities Initiative as evidenced by their many letters of support and by the positive results of surveys conducted at the facilities

The **Large Hadron Collider** - The foremost high energy physics research facility of the next decade will be the Large Hadron Collider (LHC) at CERN, the European Center for Particle Physics. The primary physics goals of the LHC will impact our understanding of the relation of mass, fundamental forces, and the structure and origin of the universe. U.S. participation in the LHC is required to provide U.S. access to the high energy frontier in order to maintain the U.S. as a world leader in this fundamental area of science.

The LHC is an outstanding example of international cooperation in large scientific projects, as well as interagency and inter-laboratory cooperation. An International Cooperation Agreement has been negotiated between CERN, DOE and NSF. The Agreement provides for U.S. participation in the construction of the accelerator, and of the two very large detectors, ATLAS and CMS. Carefully defined lists of deliverables and costs have been agreed upon for each of these areas of participation. U.S. costs are capped at $531M ($450M DOE and $81M NSF), consistent with Congressional guidance. In return, participating U.S. universities and laboratories will join, as full partners, in LHC experiments. In addition, a Memorandum of Understanding (MOU) has been executed between DOE and NSF that defines the relationship between the agencies relative to programmatic coordination of U.S. LHC activities include joint oversight and execution of the U.S. LHC Construction Program.

Under the terms of this MOU, Fermilab is the Lead Laboratory for the accelerator portion of the program, which it will execute in cooperation with Brookhaven (BNL) and Lawrence Berkeley (LBNL) National Laboratories. BNL is the host laboratory for the ATLAS portion of the program, which also involves Argonne National Laboratory (ANL) and LBNL along with 28 university groups. Similarly, Fermilab is the host laboratory for the CMS detector portion of the program, including BNL and Los Alamos National Laboratory (LANL) along with 33 university groups. Cost and schedule baselines have been reviewed and validated for each of the three programs and management systems are in place to monitor progress against baselines.

The **Next Generation Internet** (NGI) - The program is creating the foundation for more powerful and versatile networks of the 21st century, just as previous federal investments in information technology R&D created the foundation for today's Internet. This program is critical to DOE’s science and technology missions because enhancements to today’s Internet from commercial R&D will not be sufficient to enable effective use of: petabyte/year High Energy and Nuclear Physics facilities such as the Relativistic Heavy Ion Collider (RHIC); to provide remote visualization of terabyte to petabye data sets from computational simulation; to develop advanced collaboratories; and to enable effective remote access to tomorrow's advanced scientific computers.

For example, typical RHIC experimental collaborations involve thousands of scientists at hundreds of institutions across the country and the world. Using the current Internet, it would take about 2,500 hours to transmit one day's data from RHIC to one remote site for analysis. Using NGI it would take 25 hours.

Thus, DOE's NGI research program is focused on discovering, understanding, developing, testing and validating the networking technologies needed to enable wide area, data intensive and collaborative computing. The DOE applications share two important characteristics. They all involve extremely large data sets and they all require that scientists be able to interact with the data in (nearly) real time. Current network technology limitations significantly limit our ability to address these characteristics.

The DOE program includes research in advanced protocols, special operating system services for very high speed, and very advanced network control, the components needed to enable wide area, data intensive and collaborative computing. In addition the DOE program addresses issues that result from the many different kinds of network devices, network-attached devices, and services that need to be integrated together. Examples of the components and services that need to be integrated include: network resources, data archives on tape, high performance disk caches, visualization and data analysis servers, authentication and security services, and the computer on a scientist's desk. This type of integration, as well as the issues of improving the performance of the individual components, all require significant research because the issues are currently not well understood. Indeed, the first identification of many of these issues is the result of previous work in collaboratories and visualization supported by DOE.

Thus, DOE's participation in the NGI builds on previous DOE research and its over two decades of success in using advanced networks as tools for science. Furthermore, the differences between the requirements of commercial networks and networks for scientific research require DOE to conduct this research because these tools and technologies will not be developed by commercial R&D. However, the results and “spinoffs” of this research, after testing and prototyping by the scientific community, will impact broad commercial use of networks. DOE’s FY 2000 NGI program will build on the results of the competitive research solicitations conducted in FY 1999.

Climate Change Technology Initiative (CCTI)- Eighty-five percent of our Nation’s energy results from the burning of fossil fuels, a process that adds carbon to the atmosphere. Because of the potential environmental impacts of increases in atmospheric carbon dioxide, carbon management has become an international concern and is a focus of the CCTI.

The Office of Science is well positioned to make significant contributions to the many solutions needed to address this problem. SC can build on the fundamental discoveries of core research programs in carbon and non-carbon energy sources, carbon sequestration, and carbon recycling, extending them to the new discoveries needed to make carbon management practical and efficient.

Activities in both Basic Energy Sciences and Biological and Environmental Research support the DOE and Administration CCTI efforts in: *science for efficient technologies, fundamental science underpinning advances in all low/no carbon energy sources, and sequestration science.*

The SC portion of the CCTI leverages the foundation of excellent research already underway. The additional SC effort will also have a major impact on many scientific disciplines by advancing the state of knowledge in such fields as genome science, molecular, cellular and structural biology, biochemistry, chemical dynamics, solid state chemistry, photochemistry, ecology, nano- and meso-phase materials science, condensed matter physics, engineering, theoretical chemistry and physics.

For example, the BER microbial genome program has made significant investments in the technology that enables genome sequencing at rates previously unattainable. Capitalizing on these investments, the genomes of microbes that produce methane and hydrogen from carbonaceous sources will be sequenced as part of the first awards under CCTI. This will enable identification of key genetic components of the organisms that regulate the production of these gases. The carbon sequestration research program will focus on understanding the natural terrestrial sequestration cycle and the natural oceanic sequestration cycle as part of the first awards under the CCTI. The ultimate goal is to enhance the natural carbon cycle in both the terrestrial and oceanic systems. The search for new fuel sources and carbon sequestration research are key elements of the carbon management program.

CCTI research and related activities within the Office of Science will continue to be coordinated with the Office of Fossil Energy. FY 1999 integration efforts include the coordination of new CCTI proposal solicitations and preparation of a detailed carbon dioxide sequestration roadmap.

Genome - In only its first full year of operation, the DOE Joint Genome Institute (JGI) became the second leading public producer of high quality human DNA among U.S. sequencing centers. The JGI is boldly scaling up its sequencing capacity from 21 million finished bases in FY 1998 to 30 million finished bases and 40 million high quality draft bases in FY 1999. In total, SC will complete sequencing of 50 million finished and 70 million high quality draft subunits of human DNA to submit to publicly accessible databases in FY 2000. In addition, SC will complete the full genetic sequencing of more than 10 microbes that have significant potential for waste cleanup and energy production.

Improvements in high throughput human DNA sequencing technology and sequence data management are needed to complete the first human genome by 2003 and to efficiently and cost effectively use that sequence information for future medical diagnoses and scientific discovery. The Joint Genome Institute, in which the National Laboratories work as a system, are primarily focused on high throughput sequencing. FY 2000 is the third year of a major 3-5 year scale-up in DNA sequencing capability for this virtual institute. DOE will continue to work with the private sector, where appropriate, to accelerate progress and reduce cost in the Human Genome project.

The SC program is actively involved with other federal agencies funding, human, plant and microbial research to encourage effective and efficient management of the total federal genome research portfolio.

Recent Successes of the Office of Science:

Fueling the Future:

- Identified a major error in current models of combustion process
- Provided a realistic picture of corrosion resistance to advance protection coatings
- Created electrically conducting nano-scale ropes, 50-100 times more conductive than copper

Protecting our Living Planet:

- Research on “Conan the Bacterium” (D. Radiodurans) helps in clean-up
- Two of the 1997 “11 hottest papers in biology” were for microbial genomic sequences funded by SC
- Discovered gene for kidney disease

Exploring Energy and Matter:

- Launched the Alpha Magnetic Spectrometer experiment on the Space Shuttle to explore the mysteries of missing anti-matter and dark matter
- Established the 3-D, atom-by-atom structure of the enzyme system responsible for DNA replication
- Demonstrated that the supposedly massless neutrino must, in fact, have a non-zero rest mass.

Extraordinary Tools:

- Signed the Large Hadron Collider agreement opening the frontier of high energy physics to American researchers
- New scientific research facilities on-line: the William R. Wiley Environmental Molecular Sciences Laboratory; the Jefferson Lab’s Large Acceptance Spectrometer; SLAC’s B-Factory, the Oak Ridge Free-Air CO_2 Enrichment Facility and the JGI Production (DNA) Sequencing Facility.
- Projects on time and budget: Fermilab’s Main Injector, the Relativistic Heavy Ion Collider, the Combustion Research Facility Phase II, and the SNS.

SC Program Direction:

- Hammer award for Environmental Management Science Program
- Jointly developed the third DOE-NIH Human Genome Five Year Plan with accelerated sequencing goals
- Acknowledged as model for facilities management by the National Academy of Public Administrators (NAPA).

In addition, hundreds of principal investigators, funded by SC, win dozens of major prizes and awards sponsored by the President, the Department, the National Academy of Sciences, the National Academy of Engineering, and the major professional societies. These include the 1997 Nobel Prize for Chemistry, the 1997 Fermi and Lawrence awards, the National Science Foundation Career Award, eight of the 1998 R&D 100 awards, 1997 Discover Awards, the 1998 Federal Laboratory Consortium Award, and the 1997 and 1998 “Top Ten Contributions to Science,” reported by *Science* Magazine.

Major Program Activities for FY 2000:

The **Basic Energy Sciences** (BES) program is a principal sponsor of fundamental research for the United States in the areas of materials sciences, chemical sciences, geosciences, biosciences, and engineering sciences. This research underpins the DOE missions in energy, the environment and national security; advances energy related basic science on a broad front; and provides unique national user facilities for the scientific community. Performance measurement, dominated by peer review, helps to determine the distribution of activities supported within BES and the individual projects supported within each activity. The program funds more than 2,400 researchers at 200 institutions nationwide. Program results continue to be recognized through the receipt of major prizes and awards from the scientific community.

BES also plays a major part in the FY 2000 Office of Science initiatives described above. BES is the sole supporter of the Spallation Neutron Source construction and a major contributor to the Scientific Simulation Initiative (Combustion and Fundamental Research portions), Scientific Facilities Utilization, and the Climate Change Technology Initiative.

BES plans, constructs, and operates 18 major scientific user facilities to serve over 6,000 researchers at universities, national laboratories, and industry. These facilities enable the acquisition of new knowledge that often cannot be obtained by any other means. These facilities have an enormous impact on science and technology, ranging from determinations of the structure of superconductors and biological molecules to the development of wear-resistant prostheses; from atomic-scale characterization of environmental samples to elucidation of geological processes; and from the production of unique isotopes for cancer therapy to the development of new medical imaging technologies. As part of its commitment to excellence, BES user facilities maintain a record of less than 10 percent unscheduled downtime, on average.

Facility enhancements and maintenance activities for BES in FY 2000 will be focused on the existing high-flux neutron sources, the Los Alamos Neutron Science Center at Los Alamos National Laboratory and the High Flux Isotope Reactor at Oak Ridge National Laboratory. These improvements, recommended by the Basic Energy Sciences Advisory Committee, will substantially increase the neutron flux and instrument capabilities available to the scientific community. BES is committed to keeping the development and upgrade of scientific user facilities, including the construction of the Spallation Neutron Source, on schedule and within cost, not to exceed 110 percent of estimates.

Within the base research effort, the program in Complex and Collective Phenomena, started in FY 1999, will continue to support work at the frontiers of basic research that hold the promise of delivering revolutionary breakthroughs. This effort is designed to obtain fundamental knowledge of increasingly complex systems in order to help bridge the gap in our understanding between the atomic and molecular properties and the bulk structural and mechanical properties of materials, for example. In addition, BES will continue its Partnership for Academic-Industrial Research (PAIR) program to facilitate research partnerships between academic researchers, their students, and industrial researchers.

The **Biological and Environmental Research** (BER) program in FY 2000 will focus on sequencing the human genome, microbial genome research, low dose exposure research, environmental processes research with an emphasis on global environmental change, environmental remediation research, and radiopharmaceutical research, structural biology, and molecular nuclear medicine.

Last year, *Science* magazine identified genomic sequencing as one of the top ten breakthroughs in science. BER's Microbial Genome Program supported the complete genomic sequencing of 6 of the 18 bacteria sequenced with at least 12 more in progress. Microbial genome research continues to sequence microbes relevant to DOE mission needs including work in three main areas: (1) microbial diversity, to identify potentially useful microbes, (2) new DNA sequencing strategies to rapidly and cost effectively determine the sequence of closely related microbes, and (3) novel strategies and tools for characterizing, manipulating, and modeling entire reaction pathways or gene regulatory networks. Microbes are used as models to understand more complex biology and to advance sequencing tools.

In FY 2000, human DNA sequencing continues to ramp up. The DOE Joint Genome Institute will sequence 50 million finished bases and 70 million high quality draft bases of human DNA.

Radiopharmaceutical research and molecular nuclear medicine will continue to develop more specific and sensitive radiopharmaceutical tracers and develop sensitive imaging technology that will impact clinical medicine. Positron Emission Tomography (PET) technology, developed previously in this program, will be used to elucidate complex biomedical problems such as the neurochemical basis of addictive and neurodegenerative diseases. Recent work has shown damage to the brain function in persons addicted to drugs, such as cocaine, that reinforces the craving for these drugs. The Boron Neutron Capture Therapy Program will complete Phase I trials to determine an effective and safe treatment dose and initiate a Phase II efficacy trial. BER will continue to exploit the unique capabilities of the National Laboratories in a national biomedical engineering program to develop novel medical technologies.

In FY 2000, The Atmospheric Radiation Measurement facility will begin operations of the third climate observatory in the Tropical Western Pacific on Christmas Island, thus completing the span of observatories across the Pacific warm pool. Valuable data will result for climate model development and improvement.

The Free Air Carbon Dioxide Enrichment (FACE) experiment will continue tree growth and physiological observations, including studies of ecosystem processes. FACE technologies have achieved international recognition, with FACE facilities developing in Europe and Panama. FACE has observed the effect of increased atmospheric concentrations of carbon dioxide on tree growth and physiology.

BER facilities in support of fundamental science to underpin environmental cleanup continue to have an impact. After its first full year of operation in 1998, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL) had already attracted nearly 600 outside users and collaborators from government laboratories, private industry, and academia. Interactions between EMSL and the Natural and Accelerated Bioremediation Research (NABIR) program will be strengthened, to provide unifying research facilities for academic and laboratory investigators in the fields contributing to bioremediation research.

BER also plays a major part in the FY 2000 Office of Science initiatives described above. BER is the primary supporter of SC Genome research, and a major contributor to SSI (Global Systems and Fundamental Research portions), Scientific Facilities Utilization, and the CCTI.

The **High Energy Physics** (HEP) program will continue to address new and exciting research at the forefront of particle physics.

At Fermilab, the newly upgraded D-Zero and CDF detectors will be moved into position at the Tevatron; and they, along with the newly commissioned Main Injector, will be used for the first time for antiproton-proton collisions. The Main Injector will increase the luminosity of the Tevatron by a factor of 5. Also at Fermilab, the

NuMI/ MINOS neutrino oscillation project will be well underway with construction of conventional facilities and technical components; and the Wilson Hall Safety Improvements Project will be progressing well in its second year of physical construction with completion scheduled for 2002.

SLAC's newly commissioned B-factory, a collaboration among SLAC, Lawrence Berkeley National Laboratory, and Lawrence Livermore National Laboratory, will be in its first full year of operation with its primary goal to obtain high luminosity to begin the study of CP-violation (matter-antimatter asymmetry). Also at SLAC, physical construction on a new office building for B-factory users will begin.

As planned, the Alternating Gradient Synchrotron (AGS) at Brookhaven was transferred to the Nuclear Physics program for use as an injector for RHIC. Therefore, use of the AGS for high energy physics in FY 2000 will be on an incremental cost basis. AGS runs, necessary to achieve the precision measurement of the muon g-2 anomalous magnetic moment, will continue in FY 2000.

The fabrication of components for the LHC project continues in FY 2000. Fermilab is the host and lead laboratory for the U.S. efforts on the CMS detector as well as host and lead laboratory, with the assistance of Brookhaven and Lawrence Berkeley, on the U.S. accelerator efforts. Similarly, Brookhaven is the host and lead laboratory for the U.S. efforts on the ATLAS detector.

In addition, R&D on accelerator concepts for future large accelerator facilities will continue in FY 2000. Consistent with recent HEP Advisory Panel recommendations, modest increases are planned for high energy physics university groups in FY 2000 to allow them to exploit new facilities mentioned above.

The **Nuclear Physics** (NP) program provides primary support in the U.S. for fundamental research on the structure and fundamental forces in atomic nuclei. The Program operates large and small particle accelerator facilities located at National Laboratories and Universities which provide the microscopic probes of these structures and forces. The scope of the FY 2000 Nuclear Physics Program is broadly enhanced by operation of several new facilities. The new Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory will operate for its first full year to search for the predicted quark-gluon plasma, a heretofore unseen form of nuclear matter. The new Thomas Jefferson National Accelerator Facility in Newport News, Virginia, is fully operational, and will continue an already impressive program of research into the quark basis of the structure of nuclei. The Sudbury Neutrino Observatory (SNO) in Canada will be fully operational in FY 2000 and will be accumulating important information on the apparent low rate of neutrino flux from the sun. R&D and conceptual design development for a proposed world-class radioactive ion beam facility (ISOL) for nuclear structure and astrophysics studies, will be supported in FY 2000. A smaller radioactive ion beam facility (RIB) has recently begun to operate at Oak Ridge National Laboratory, and is prototyping new radioactive beam techniques as well as doing research.

Unique low energy heavy ion facilities at ANL and LBNL, will continue to pursue important investigations of highly deformed and exotic nuclei which require examination using very high resolution spectroscopy. The new and highly successful Gammasphere detector is being utilized at both ANL and LBNL to pursue such experiments. The MIT/Bates Linear Accelerator Center, which has been a major world center for nuclear research using electron scattering for over 25 years, will end operations in FY 2000.

The **Fusion Energy Sciences** (FES) program is completing its transition from a focus on the development of fusion as a new energy supply technology to emphasizing the science that underpins fusion energy. In FY 2000, the program will continue to make progress in understanding plasma physics, identifying and exploring innovative approaches to fusion power, and exploring the science and technology of energy producing plasmas, as a partner in the international fusion research effort.

FY 2000 will begin a three year effort, supported by FES, at the Princeton Plasma Physics Laboratory (PPPL) for the decontamination and decommissioning of the Tokamak Fusion Test Reactor (TFTR).

The program continues the move toward innovation and increased understanding of a wide range of confinement concepts. The National Spherical Torus Experiment (NSTX) facility provides strong support of the goal to explore innovative and more affordable development paths. Work on concept improvement at the exploratory level in both physics and enabling technology R&D will receive more emphasis. The inertial fusion energy element will be broadened to include research efforts on systems and related elements. This change in domestic program emphasis reflects a move away from the costly, large scale devices aimed at providing integrated plasma technology experiments operating with power plant-scale plasma parameters.

The International effort to explore the science and technology of energy producing plasmas was dramatically reduced in FY 1999 by termination of U.S. participation in the International Thermonuclear Experimental Reactor (ITER) project. The U.S. will, however, continue to pursue modest scale international collaborative activities on major international scientific facilities.

Research on high temperature toroidal plasmas will be carried out using the DIII-D facility at General Atomics, C-MOD at MIT and NSTX spherical torus at PPPL which will have its first full year of operations in FY 2000. The experimental program will be supported by broadly based theoretical, modeling and computational efforts. Technology activities supporting energy-producing plasmas will be drastically reduced as part of the shift in priorities noted above, but the long range program on low activation materials will continue. The physical and intellectual infrastructure associated with the experimental portion of energy producing plasmas will need to be re-established at an appropriate time depending upon technical advances toward lower-cost systems and/or increased urgency.

As recommended by Congress, a review of the several approaches to fusion (to be conducted by the Secretary of Energy Advisory Board) was initiated in December, 1998 and will be completed in May 1999. The National Academy of Sciences is also expected to complete a review of the fusion science program in FY 1999. Recommendations from these reviews will help to set the course for future fusion research activities.

The **Computational and Technology Research** (CTR) program supports advanced computing research — applied mathematics, high performance computing, networking, and operates supercomputer and associated facilities that are available to researchers 24 hours a day, 365 days a year. The combination of support for fundamental research, computational and networking tools development, and high-performance computing facilities provides scientists with the capabilities to analyze, model, simulate, and — most importantly — predict complex phenomena of importance to the Office of Science and the Department of Energy.

The long history of CTR accomplishments continued in FY 1999 including: the 1998 Gordon Bell Prize for Best Performance of a Supercomputing Application, the 1998 IEEE Fernbach Award for outstanding contribution in the application of high performance computers using innovative approaches and four R&D 100 Awards to CTR researchers in areas ranging from parallel numerical libraries to near frictionless coatings.

Experiments at Office of Science facilities may generate millions of gigabytes (petabytes) of data per year (which would fill the disk drives of millions of today's personal computers) presenting significant computational and communications challenges in analyzing and extracting information from the data.

Some of the pioneering accomplishments of this program are: development of the technologies to enable remote, interactive access to supercomputers; research and development leading to the High Performance Parallel Interface (HiPPI) standard; and research leading to the development of the slow start algorithm for the Transmission Control Protocol (TCP), which enabled the Internet to scale to today's worldwide communications infrastructure.

CTR is responsible for DOE participation in the Next Generation Internet (NGI) program to create the foundation for more powerful and versatile networks of the 21st century.

CTR also heads the Department's Scientific Simulation Initiative (SSI) as a joint program with the other program offices in SC. CTR's role in the SSI includes management of the selection process for a small number of basic science application efforts initiated in FY 2000, management of the SSI Advanced Computing and Communications Facilities, and management of the Computer Science and Enabling Technology component.

In addition to these computing related activities CTR also manages the Laboratory Technology Research (LTR) program for the Office of Science. The mission of this program is to support high risk, energy related research that advances science and technology to enable applications that could significantly impact the Nation's energy economy. LTR fosters the production of research results motivated by a practical energy payoff through cost-shared collaborations between Office of Science laboratories and industry.

The Science **Program Direction** budget funds staff and related expenses which are necessary to provide overall management direction of the Office of Science research programs. The Office of Science will strive to meet staffing levels as outlined in its Workforce Management Plan. Work will continue on piloting the transfer of management responsibility of newly generated wastes at SC sites from Environmental Management to the Office of Science. The scientific and technological challenges of the Department's missions demand an adequate supply of scientists, engineers and technicians. For over 50 years, DOE and its predecessor agencies have supported science and engineering education programs involving university faculty as well as pre-college teachers and students. Tapping the significant human and physical resources of the DOE National Laboratories is perhaps the most distinguishing feature of the agency's contribution to science education. Within the FY 2000 request for Program Direction is SC's core program for science education, supporting such activities as: the Undergraduate Research Fellowship Program, the National Science Bowl, and Albert Einstein Distinguished Educator Fellowship. In addition, two new initiatives, developed in partnership with NSF, will be supported through the five SC scientific programs. The first initiative will be focused on providing pre-college science and math teachers with research opportunities that will improve their knowledge and skills of scientific discovery and enhance their ability to apply them in their classrooms. The second initiative will allow university faculty and undergraduate student teams to participate in long-term research projects at DOE Laboratories. Historically, over two-thirds of undergraduates who have participated in DOE programs have gone on to graduate school in disciplines directly related to DOE missions. These activities will help to fulfill SC's responsibilities in developing the next generation of scientists and engineers in a responsible and focused manner.

Effective human resource management will ensure that critical staffing needs are met in support of the strategic goals of the Department. This includes, but is not limited to, the integration of diversity considerations into all human resource management activities, and effective long-term succession planning for executives and scientific/ technical positions. Enhanced business processes that are built from our Activity Based Management activities and Strategic Information Planning will enable the staff to carry out the mission and functions of the organization effectively and efficiently.

Closing:

The significant increase in the FY 2000 budget for the Office of Science recognizes the critical role that fundamental knowledge plays in achieving the DOE missions and for the general advance of the Nation's economy and the welfare of its citizens. The Scientific Simulation Initiative represents a major investment in producing the necessary scientific computation and information infrastructure for DOE science applications as part of a multi-agency initiative. This request will also provide the U.S. scientific community with increased research capability and new opportunities at the DOE scientific user facilities, including progress on SNS, a new forefront neutron source, and upgrades of existing facilities. On behalf of the Administration and the Department, I am pleased to present this budget for the Office of Science and welcome the challenge to deliver results.

Martha Krebs
Director
Office of Science

Table 1

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
Science			
Basic Energy Sciences	651,816	799,524	888,084
Computational and Technology Research	146,779	157,471	198,875
Biological and Environmental Research	395,676	436,688	411,170
Fusion Energy Sciences	224,190	222,636	222,614
High Energy Physics	668,590	695,526	697,090
Nuclear Physics	314,738	334,555	342,940
Energy Research Analyses	1,434	1,000	1,000
Multiprogram Energy Laboratories-Facilities Supp	21,247	21,260	21,260
Science Program Direction	37,600	49,800	52,360
Small Business Innovation Research and Small Business Technology Transfer	80,730	——	——
Subtotal	2,542,800	2,718,460	2,835,393
General Reduction for Use of Prior Year Balances	-15,295	-13,000	——
Superconducting Super Collider	-35,000	-7,600	——
Total	2,492,505	2,697,860	2,835,393
Energy Supply R&D			
Technical Information Management	10,100	8,600	9,100
General Reduction for Use of Prior Year Balances	-68	-191	——
Total	10,032	8,409	9,100

Table 2

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
Global Climate Change	105,780	113,865	124,838
Climate Change Technology Initiative	——	13,500	33,000
Partnership for New Generation of Vehicles	5,000	5,000	5,000
Science and Education Programs	——	4,500	14,235
Strategic Simulation Initiative	——	——	70,000

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
AMES LABORATORY			
Basic Energy Sciences	18,659	17,114	16,967
Biological and Environmental Research	766	631	500
Computational and Technology Research	2,290	1,939	1,490
High Energy Physics	——	——	219
Total Laboratory	21,715	19,684	19,176
ARGONNE NATIONAL LABORATORY			
Basic Energy Sciences	139,894	143,436	145,096
Biological and Environmental Research	11,278	9,181	13,476
Computational and Technology Research	16,869	15,430	8,187
Fusion Energy Sciences	2,835	2,540	2,135
High Energy Physics	9,512	8,825	9,040
Multiprogram Energy Labs-Facilities Support	10,892	7,089	4,980
Nuclear Physics	16,845	16,045	17,485
Total Laboratory	208,125	202,546	200,399
BROOKHAVEN NATIONAL LABORATORY			
Basic Energy Sciences	76,722	77,586	77,331
Biological and Environmental Research	26,501	22,142	19,228
Computational and Technology Research	2,843	1,457	2,589
Fusion Energy Sciences	50	——	——
High Energy Physics	86,774	62,813	32,769
Multiprogram Energy Labs-Facilities Support	568	1,349	6,881
Nuclear Physics	110,851	115,900	135,549
Total Laboratory	304,309	281,247	274,347

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
THOMAS JEFFERSON NATIONAL ACCELERATOR FACILITY			
Basic Energy Sciences	200	——	——
Computational and Technology Research	190	100	283
Nuclear Physics	68,850	70,305	73,669
Total Laboratory	69,240	70,405	73,952
FERMI NATIONAL ACCELERATOR LABORATORY			
Computational and Technology Research	100	50	332
High Energy Physics	278,873	283,301	291,788
Total Laboratory	278,973	283,351	292,120
IDAHO NATIONAL ENGINEERING LABORATORY			
Basic Energy Sciences	3,478	3,609	3,020
Biological and Environmental Research	2,158	2,034	1,736
Fusion Energy Sciences	4,120	1,740	1,000
Nuclear Physics	90	80	80
Total Laboratory	9,846	7,463	5,836
LAWRENCE BERKELEY NATIONAL LABORATORY			
Basic Energy Sciences	62,160	62,553	62,095
Biological and Environmental Research	34,358	31,587	29,003
Computational and Technology Research	57,916	53,938	49,377
Energy Research Analyses	100	——	——
Fusion Energy Sciences	3,947	5,334	5,255
High Energy Physics	26,869	24,492	35,532
Multiprogram Energy Labs-Facilities Support	2,400	4,854	6,133
Nuclear Physics	21,965	22,118	18,080
Total Laboratory	209,715	204,876	205,475

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
LAWRENCE LIVERMORE NATIONAL LABORATORY			
Basic Energy Sciences	5,933	6,044	5,236
Biological and Environmental Research	30,004	36,148	28,446
Computational and Technology Research	2,755	2,940	640
Fusion Energy Sciences	10,518	11,158	10,168
High Energy Physics	1,794	685	680
Nuclear Physics	845	660	950
Total Laboratory	51,849	57,635	46,120
LOS ALAMOS NATIONAL LABORATORY			
Basic Energy Sciences	23,613	24,673	25,906
Biological and Environmental Research	19,661	20,651	18,251
Computational and Technology Research	14,614	13,034	10,894
Fusion Energy Sciences	4,143	4,219	4,419
High Energy Physics	1,090	650	790
Nuclear Physics	10,783	9,750	10,260
Total Laboratory	73,904	72,977	70,520
OAK RIDGE NATIONAL LABORATORY			
Basic Energy Sciences	110,219	217,848	302,898
Biological and Environmental Research	25,422	21,617	19,153
Computational and Technology Research	19,434	10,415	6,876
Energy Research Analyses	665	——	400
Fusion Energy Sciences	17,870	17,480	15,866
High Energy Physics	772	240	240
Multiprogram Energy Labs-Facilities Support	7,387	6,808	2,106
Nuclear Physics	16,215	15,017	16,665
Total Laboratory	197,984	289,425	364,204

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
PACIFIC NORTHWEST NATIONAL LABORATORY			
Basic Energy Sciences	12,868	12,788	12,947
Biological and Environmental Research	77,466	73,913	70,434
Computational and Technology Research	4,188	3,238	3,584
Energy Research Analyses	——	——	250
Fusion Energy Sciences	1,415	1,410	1,430
High Energy Physics	10	10	10
Total Laboratory	95,947	91,359	88,655
NATIONAL RENEWABLE ENERGY LABORATORY			
Basic Energy Sciences	4,515	4,193	3,744
Biological and Environmental Research	250	——	——
Computational and Technology Research	498	127	——
Total Laboratory	5,263	4,320	3,744
PRINCETON PLASMA PHYSICS LABORATORY			
Basic Energy Sciences	700	675	——
Computational and Technology Research	90	121	332
Fusion Energy Sciences	49,612	50,332	58,979
High Energy Physics	80	120	534
Total Laboratory	50,482	51,248	59,845
SANDIA NATIONAL LABORATORY			
Basic Energy Sciences	28,764	26,600	22,008
Biological and Environmental Research	3,486	3,239	2,903
Computational and Technology Research	5,232	5,293	3,779
Fusion Energy Sciences	5,850	4,115	3,565
Total Laboratory	43,332	39,247	32,255

Table 3

OFFICE OF SCIENCE
FY 2000 PRESIDENT'S BUDGET REQUEST TO CONGRESS
(B/A in thousands of dollars)

Major Site Funding	FY 1998 Current Approp.	FY 1999 Current Approp.	FY 2000 Request
STANFORD LINEAR ACCELERATOR CENTER			
Basic Energy Sciences	21,684	22,686	21,968
Computational and Technology Research	980	357	782
Biological and Environmental Research	3,323	2,450	2,550
Fusion Energy Sciences	50	50	50
High Energy Physics	147,502	145,017	150,231
Nuclear Physics	9	——	——
Total Laboratory	173,548	170,560	175,581

High Energy Physics

Program Mission

The High Energy Physics (HEP) program of the Department of Energy (DOE) has the lead responsibility for Federal support of high energy physics research and supports fundamental research activities under the mandate provided in Public Law 95-91 which established the Department. The High Energy Physics program is a key element in the Science and Technology component of the DOE Strategic Plan, supporting several of the strategies which make up that component. This program is also one of the identified elements in the Secretary's Performance Agreement with the President, and is an integral part of the Department's fundamental research mission. The program is directed at understanding the nature of matter and energy at the most fundamental level, and the basic forces which govern all processes in nature. Fundamental research provides the necessary foundation that ultimately enables the Nation to progress in its science and technology capabilities, to advance its industrial competitiveness, and to discover new and innovative approaches to our energy future.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

Provide new insights into the nature of energy and matter to better understand the natural world.

Program Objectives

- *To continue to support high quality research* — Support high quality university and laboratory based high energy physics research, both theoretical and experimental. Experimental research is primarily performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad.
- *To effectively operate the department's high energy physics accelerator facilities* — Provide optimal and cost effective operation for research of the Fermi National Accelerator Laboratory, and the Stanford Linear Accelerator Center. The Alternating Gradient Synchrotron complex at the Brookhaven National Laboratory will be transferred to the Nuclear Physics (NP) program during FY 1999.
- *To continue to provide world class research facilities* — Plan for and build new, state-of-the-art research facilities that allow researchers to advance the forefront of the science of high energy physics. Support essential improvements and upgrades at the major accelerator laboratories. Manage the commissioning of the Fermilab Main Injector project, the initial operation of the B-factory at SLAC and the continuation of the new experimental facility at Fermilab called Neutrinos at the Main Injector (NuMI).

- *To continue to provide the program's technological base* — Support long-range accelerator and detector R&D required to provide the advanced concepts and technologies which are critical to the long-range viability of high energy physics research.
- *To continue to pursue international collaboration on large high energy physics projects* — Work to put into place the management and control systems needed to successfully carry out the planned and agreed to collaboration with CERN on the Large Hadron Collider (LHC) project. Work to explore and pursue other opportunities for effective and beneficial international collaborative activities.

Scientific Facilities Utilization

The High Energy Physics request includes $439,814,000 to maintain support of the Department's scientific user facilities. This investment will provide significant research time for thousands of scientists in universities, and other Federal laboratories. It will also leverage both Federally and privately sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment. The proposed funding will support operations at the Department's two major high energy physics facilities: the Tevatron at Fermilab, and the B-factory at the Stanford Linear Accelerator Center (SLAC), and on an incremental basis will provide support for limited operation of the Alternate Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL), which is primarily being operated as part of the Nuclear Physics (NP) funded Relativistic Heavy Ion Collider (RHIC) complex.

Performance Measures

Performance measures related to basic science activities are primarily qualitative rather than quantitative. The scientific excellence of the High Energy Physics program is continually reevaluated through the peer review process. Some specific performance measures are:

- Quality of scientific results and plans as indicated by expert advisory committees, recognition by the scientific community, and awards received by DOE-supported High Energy Physics researchers. The results of these reviews and other quality measures will be used to determine programmatic directions aimed at maintaining the world leadership position of the U.S. high energy physics program.
- Sustained achievement in advancing knowledge, as measured by the quality of the research based on results published in refereed scientific journals, and by the degree of invited participation at national and international conferences and workshops.
- Operation of research facilities in a manner that meets user requirements, as indicated by achieving performance specifications while protecting the safety of the workers and the environment, and by the level of endorsement by user organizations; operating facilities that are used for research at the forefront of science; and operating facilities reliably and according to planned schedules.
- Progress on the Neutrinos at the Main Injector project as measured by accomplishment of scheduled milestones; progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on achieving luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.

- The upgrade of scientific facilities will be managed to keep them on schedule and within cost.
- High Energy Physics will begin operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab, and will deliver on the FY 2000 U.S./DOE commitments to the international Large Hadron Collider project.
- Review at least 80 percent of the research projects by appropriate peers and selected through a merit-based competitive process.
- Continue collaborative efforts with NASA on space science.

Significant Accomplishments and Program Shifts

- Completion of a long range planning study of the High Energy Physics program was accomplished by a Subpanel of the High Energy Physics Advisory Panel (HEPAP), (Gilman report). Their report is entitled "Planning for the Future of U.S. High-Energy Physics." The Subpanel's recommendations were considered carefully in preparing this budget.

Research and Technology

- Measurement, by teams of university and laboratory scientists working at Fermilab, of the mass and production properties of the top quark was accomplished. This is the last, and by far the heaviest, of the fundamental building blocks of matter (quarks) whose existence was predicted by the Standard Model of elementary particles. The mass of the top quark is now measured more accurately than any of the other quarks.
- The world's most precise measurement was made, by a team of university and laboratory scientists working at Fermilab, of the mass of the W boson. This result is considerably more precise than the best measurement from LEP.
- The world's highest precision single measurement was made by a group of university and laboratory scientists working at SLAC, of the weak mixing angle, a fundamental parameter of the Standard Model.
- The observation was made, by the CDF collaboration working at Fermilab, of the B meson containing a charmed quark. This discovery completes the theoretically predicted family of B mesons.
- The observation was made for the first time ever by the kTeV collaboration of the predicted decay of the kaon into a pair of pions and an electron-positron pair.
- A major advance in theoretical physics was achieved when it was shown and verified that all of the known "string" theories are equivalent. This greatly reduces the number of possible theories which describe all of the known forces including gravity.
- A test of a superconducting accelerator-style magnet fabricated at Lawrence Berkeley National Laboratory (LBNL) achieved a new world record field strength of 13.5 teslas (previous record 11 teslas.) This is a significant accomplishment in the effort to advance technology for future accelerators.
- At the g-2 experiment at BNL, designed to study the magnetic properties of the muon and to develop a more precise measurement of the anomalous magnetic moment, initial data collection has been

completed. Once data collection has been completed, the analysis of these data should become available over the next three years. The experimenters are confident that they will achieve the world's best measurement of the anomalous magnetic moment of the muon. If the final result agrees with the standard model, it will place significant new limits on physics beyond the standard model.

Facility Operations

- The final data collection with the Fermilab 800 GeV fixed-target program will be completed in FY 2000, and the prime focus of the Fermilab program will turn to research using the Tevatron collider with the higher luminosity of the new Main Injector.
- The Alternating Gradient Synchrotron at BNL will be transferred to the Nuclear Physics program for operation as the injector for the RHIC facility during the 3rd quarter of FY 1999. Beginning in FY 2000, use of the AGS for High Energy Physics experiments will be on an incremental cost basis.
- The European Center for Nuclear Research (CERN) in Geneva, Switzerland has initiated the Large Hadron Collider (LHC) project. This will consist of a 7 on 7 TeV proton-proton colliding beams facility to be constructed in the existing Large Electron-Positron Collider (LEP) machine tunnel (LEP will be removed). The LHC will have an energy 7 times that of the Tevatron at Fermilab. Thus the LHC will open up substantial new frontiers for scientific discovery.

  The Project is proceeding well. All the civil engineering contracts have been awarded and work is underway and proceeding on schedule. Work is underway for the ATLAS detector hall, for the CMS detector hall, for a beam transfer line tunnel on the Swiss side, and for a second beam transfer line tunnel together with enlargements of the main tunnel on the French side. In addition, CERN has completed approximately 700 million Swiss francs worth of contracting for the collider, which is a significant portion of the total project budget. This includes orders placed with three companies, German, Italian and French, for two full-length collider dipole magnets from each, with an option for a third.

  Participation by the U.S. in the LHC program is extremely important to U.S. High Energy Physics program goals. The LHC will become the foremost high energy physics research facility in the world around the middle of the next decade. With the LHC at the next energy frontier, American scientific research on that frontier depends on participation in LHC. The High Energy Physics Advisory Panel (HEPAP) Subpanel on Vision for the Future of High-Energy Physics (Drell) strongly endorsed participation in the LHC, and this endorsement has been restated by HEPAP on several occasions.

  The physics goals of the LHC include a search for the origin of mass as represented by the "Higgs" particle, exploration in detail of the structure and interactions of the top quark, and the search for totally unanticipated new phenomena. Although LHC will have a lower energy than the Superconducting Super Collider (canceled in 1993), it has strong potential for answering the question of the origin of mass. The LHC energies are sufficient to test theoretical arguments for a totally new type of matter. In addition, history shows that major increases in the particle energy nearly always yield unexpected discoveries.

  DOE and NSF have entered into an agreement with CERN about contributions to the LHC accelerator and detectors as part of the U.S. participation in the LHC program to provide access for U.S. scientists to the next decade's premier high energy physics facility. The resulting agreements were approved by CERN, the DOE and the NSF and were signed in December of 1997.

Participation in the LHC project (accelerator and detectors) at CERN will primarily take the form of the U.S. accepting responsibility for designing and fabricating particular subsystems of the accelerator and of the two large detectors. Thus, much of the funding will go to U.S. laboratories, university groups, and industry for fabrication of subsystems and components which will become part of the LHC accelerator or detectors. A portion of the funds will be used to pay for purchases by CERN of material needed for construction of the accelerator. As a result of the negotiations, CERN has agreed to make these purchases from U.S. vendors.

The agreement provides for a U.S. DOE contribution of $450,000,000 to the LHC accelerator and detectors over the period FY 1996 through FY 2004 (with approximately $81,000,000 being provided by the NSF). The DOE contribution is broken down as follows: detectors $250,000,000; accelerator $200,000,000 (including $90,000,000 for direct purchases by CERN from U.S. vendors and $110,000,000 for fabrication of components by U.S. laboratories).

The total cost of the LHC on a basis comparable to that used for U.S. projects is estimated at about $6,000,000,000. Thus the U.S. contribution represents less than 10 percent of the total. (The LHC cost estimates prepared by CERN, in general, do not include the cost of permanent laboratory staff and other laboratory resources used to construct the project.) Neither the proposed U.S. DOE $450,000,000 contribution nor the estimated total cost of $6,000,000,000 include support for the European and U.S. research physicists working on the LHC program.

The agreement negotiated with CERN provides for U.S. involvement in the management of the project through participation in key management committees (CERN Council, CERN Committee of Council, LHC Board, etc.). This will provide an effective base from which to monitor the progress of the project, and will help ensure that U.S. scientists have full access to the physics opportunities available at the LHC. The Office of Science has conducted a cost and schedule review of the entire LHC project and similar reviews of the several proposed U.S. funded components of the LHC. All of these reviews concluded the costs are properly estimated and that the schedule is feasible.

In addition to the proposed U.S. DOE $450,000,000 contribution and $81,000,000 NSF contribution to the LHC accelerator and detector hardware fabrication, U.S. participation in the LHC will involve a significant portion of the U.S. High Energy Physics community in the research program at the LHC. This physicist involvement has already begun. Over 500 U.S. scientists have joined the U.S.-ATLAS detector collaboration, the U.S.-CMS detector collaboration, or the U.S.-LHC accelerator consortium, and are hard at work helping to design the initial physics research program to be carried out at the LHC helping to specify the planned physics capabilities of the LHC accelerator and detectors, and helping to design and fabricate accelerator and detector components and subsystems.

Fabrication of LHC subsystems and components by U.S. participants began in FY 1998. Funding was provided in FY 1996 ($6,000,000) and FY 1997 ($15,000,000) for preliminary R&D, design and engineering work on the subsystems and components being proposed for inclusion in the agreement with CERN. This funding was essential in order to provide the cost and technical bases for the proposed U.S. responsibilities in LHC, and to be ready for rapid start to satisfy the anticipated timetable for the project. Funding in the amount of $35,000,000 was provided in FY 1998, $65,000,000 will be provided in FY 1999, and $70,000,000 in FY 2000 to support continuation of these R&D and design efforts, and the continuation of fabrication of those subsystems and components specified in the agreements with CERN.

The planned U.S. funding for the LHC project is summarized below.

U.S. LHC Accelerator and Detector Funding

(dollars in thousands)

Fiscal Year	Department of Energy			National Science Foundation[a]
	Accelerator	Detector	Total	
1996 [b]	2,000	4,000	6,000	0
1997 [b]	6,670	8,330	15,000	0
1998 [b]	14,000	21,000	35,000	0
1999	29,740	35,260	65,000	22,150
2000	31,200	38,800	70,000	15,900
2001	32,060	37,940	70,000	16,370
2002	31,200	38,800	70,000	16,860
2003	29,000	36,000	65,000	9,720
2004	24,130	29,870	54,000	0
Total	200,000 [c]	250,000	450,000	81,000

This estimated annual funding profile is based on the needs of the LHC project and is consistent with flat out year funding for the High Energy Physics program. The profile is subject to change as additional planning detail is derived. The total of $450,000,000 from DOE for the project is firm.

Construction

- The Fermilab Main Injector Project is proceeding well and is within the planned cost and schedule profiles. All relevant milestones have been met. At the end of FY 1998, the construction phase of the project was nearly complete and commissioning was underway.
- The C-Zero Experimental Hall project at Fermilab will provide a new underground experimental area at the C-Zero location on the Tevatron ring. When completed in FY 1999, this will provide space for a new program of fixed target and modest sized collider experiments now being planned at Fermilab.
- The B-factory Project at SLAC will be completed within the planned cost and schedule profiles. At the end of FY 1998, the project was essentially complete and commissioning was underway. The physics research program, using the BaBar detector will begin during FY 1999.
- The Wilson Hall Safety Improvements Project is proceeding well. An economical, safe and effective method for repairing the structural beams has been developed and detailed planning and contracting is underway.

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[a] The NSF funding has been approved by the National Science Board.

[b] The FY 1996 and FY 1997 funding was for R&D, design and engineering work in support of the proposed U.S. participation in LHC. Beginning in FY 1998 funding was used for: fabrication of machine and detector hardware, supporting R&D, prototype development, and purchases by CERN from U.S. vendors.

[c] Includes $110,000,000 for LHC supporting R&D and accelerator components to be fabricated by U.S. laboratories and $90,000,000 for purchases by CERN from U.S. vendors.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $373,000 and $270,000 for estimated contractor security clearances in FY 1999 and FY 2000, respectively, within this decision unit.

Funding Profile

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Original Appropriation	FY 1999 Adjustments	FY 1999 Current Appropriation	FY 2000 Request
High Energy Physics					
Research and Technology	209,128	215,865	-974	214,891	227,190
Facility Operations	408,612	459,635	0	459,635	441,200
Subtotal, High Energy Physics	617,740	675,500	-974	674,526	668,390
Construction	50,850	21,000	0	21,000	28,700
Subtotal, High Energy Physics	668,590	696,500	-974	695,526	697,090
Use of Prior Year Balances	-1,851 [a]	-1,610 [a]	0	-1,610 [a]	0
General Reduction	0	-974	+974	0	0
Total, High Energy Physics	666,739 [b]	693,916	0	693,916	697,090

Public Law Authorization:

Public Law 95-91, "Department of Energy Organization Act"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $12,833,000 which has been transferred to the SBIR program and $770,000 which has been transferred to the STTR program.

Funding by Site

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	%Change
Albuquerque Operations Office					
Los Alamos National Laboratory	1,090	650	790	+140	+21.5%
Chicago Operations Office					
Ames Laboratory	0	0	219	+219	+100.0%
Argonne National Laboratory	9,512	8,825	9,040	+215	+2.4%
Brookhaven National Laboratory	86,774	62,813	32,769	-30,044	-47.8%
Fermi National Accelerator Laboratory	278,873	283,301	291,788	+8,487	+3.0%
Princeton Plasma Physics Laboratory . .	80	120	534	+414	+345.0%
Total, Chicago Operations Office	375,239	355,059	334,350	-20,709	-5.8%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	26,869	24,492	35,532	+11,040	+45.1%
Lawrence Livermore National Laboratory	1,794	685	680	-5	-0.7%
Stanford Linear Accelerator Center	147,502	145,017	150,231	+5,214	+3.6%
Total, Oakland Operations Office	176,165	170,194	186,443	+16,249	+9.5%
Oak Ridge Operations Office					
Oak Ridge Institute for Science Education	230	100	489	+389	+389.0%
Oak Ridge National Laboratory	772	240	240	0	0.0%
Total, Oak Ridge Operations Office	1,002	340	729	+389	+114.4%
Richland Operations Office					
Pacific Northwest National Laboratory . .	10	10	10	0	0.0%
All Other Sites [a]	115,084	169,273	174,768	+5,495	+3.2%
Subtotal, High Energy Physics	668,590	695,526	697,090	+1,564	+0.2%
Use of prior year balances	-1,851 [b]	-1,610 [b]	0	+1,610 [b]	+100.0%
Total, High Energy Physics	666,739 [c]	693,916	697,090	+3,174	+0.5%

[a] Funding provided to universities, industry, other federal agencies and other miscellaneous contractors.

[b] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[c] Excludes $12,833,000 which has been transferred to the SBIR program and $770,000 which has been transferred to the STTR program.

Site Description

Ames Laboratory

Ames Laboratory is a Mulitiprogram Laboratory located on 10 acres in Ames, Iowa. Educational activities supported at the laboratory are directed towards providing opportunities for pre-college teachers that will participate directly in cutting-edge research at DOE science laboratories, and will renew their understanding of scientific investigation.

Argonne National Laboratory

Argonne National Laboratory in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. High Energy Physics supports a program of physics research and technology R&D at ANL, using unique capabilities of the laboratory in the areas of accelerator R&D techniques and participation in the CDF and MINOS detector collaborations.

Brookhaven National Laboratory

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. High Energy Physics supports a program of physics research and technology R&D at BNL, using unique capabilities of the laboratory, including the Accelerator Test Facility and the capability for precision experimental measurement. High Energy Physics also makes limited use of the Alternating Gradient Synchrotron which is principally supported by the Nuclear Physics program.

Fermi National Accelerator Laboratory

Fermi National Accelerator Laboratory is a program-dedicated laboratory (High Energy Physics) located on a 6,800 acre site in Batavia, Illinois. Fermilab operates the Tevatron accelerator and colliding beam facility which consists of a four mile ring of superconducting magnets and is capable of accelerating protons and antiprotons to one TeV. Thus the Tevatron is the highest energy particle accelerator in the world, and has a unique capability for research at the energy frontier. Fermilab, together with SLAC, constitute the principal experimental facilities of the DOE High Energy Physics program.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Lab is on a 200 acre site adjacent to the Berkeley campus of the University of California. High Energy Physics supports a program of physics research and technology R&D at LBNL, using unique capabilities of the laboratory primarily in the areas of participation in the BaBar collaboration, expertise in superconducting magnet R&D, and expertise in design of forefront electronic devices.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. High Energy Physics supports a program of physics research and technology R&D at LLNL, using unique capabilities of the laboratory primarily in the area of advanced accelerator R&D and participation in the B-factory project.

Los Alamos National Laboratory

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. High Energy Physics supports a program of physics research and technology R&D at LANL, using unique capabilities of the laboratory primarily in the area of theoretical studies, and computational techniques for accelerator design.

Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education is located on a 150 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small effort at ORISE in the area of program planning and review.

Oak Ridge National Laboratory

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small research effort using unique capabilities of ORNL primarily in the area of particle beam shielding calculations.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a Multiprogram Laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. The High Energy Physics program supports a small research effort using unique capabilities of PNNL in the area of low background experiments.

Princeton Plasma Physics Laboratory

Princeton Plasma Physics Laboratory is a program-dedicated laboratory (Fusion Energy Sciences) located on 72 acres in Princeton, New Jersey. The High Energy Physics program supports a small research effort using unique capabilities of PPPL in the area of advanced accelerator R&D.

Stanford Linear Accelerator Center

Stanford Linear Accelerator Center is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. SLAC operates for High Energy Physics the newly completed B-factory, the SLAC Linear Collider with the Stanford Large Detector, and a program of fixed target experiments. All of these facilities make use of the two mile long linear collider, or linac. SLAC, together with Fermilab, constitute the principal experimental facilities of the DOE High Energy Physics program.

All Other Sites

The High Energy Physics program funds research at 106 colleges/universities located in 38 states. This line also includes funding of research awaiting distribution pending completion of peer review results or program office detailed planning.

Research and Technology

Mission Supporting Goals and Objectives

The High Energy Physics program has two major subprograms. The Research and Technology subprogram provides support for the scientists who perform the research which is the core of the program, and the technology R&D, which is essential to maintain the accelerator and detector facilities at the cutting edge required for a successful research program. The Facility Operations subprogram, described later, provides the large facilities — accelerators, detectors, colliding beams devices — needed for the research program.

The Physics Research category in the Research and Technology subprogram provides support for university and laboratory based research groups conducting experimental and theoretical research in high energy physics. This research probes the nature of matter and energy at the most fundamental level, and the characteristics of the basic forces in nature. Experimental research activities include: planning, design, fabrication and installation of experiments; conduct of experiments; analysis and interpretation of data; and publication of results. Theoretical physics research provides the framework for interpreting and understanding observed phenomena and, through predictions and extrapolations based on current understanding, identifies key questions for future experimental explorations. This subprogram supports research groups at more than 100 major universities and at 9 DOE laboratories.

The High Energy Technology category in the Research and Technology subprogram provides the specialized advanced technology R&D required to sustain and extend the technology base and provide operational support for the highly specialized accelerators, colliding beams facilities, and detector facilities which are essential to the overall high energy physics program goal of carrying out forefront research. The objectives of this category include: 1) carry out R&D in support of existing accelerator and detector facilities aimed at maintaining and improving their performance parameters and cost effectiveness; 2) carry out R&D in support of planned and proposed projects to maximize their performance goals and cost effectiveness; 3) carry out R&D to transfer new concepts and technologies into practical application in the High Energy Physics context; and 4) carry out R&D to search for and develop new concepts and ideas which could lead to significant enhancements of research capabilities or to significant cost savings in the construction and operation of new facilities. This category supports work primarily at the DOE labs, but also at universities, other federal labs, and in industry.

The High Energy Physics program will provide opportunities for pre-college teachers that will participate directly in cutting-edge research at DOE science laboratories, and will renew their understanding of scientific investigation. Where teachers do not possess sufficient background to participate directly in research, DOE will provide mediated research experiences where teachers can work with teams of scientists and science educators to understand the nature of DOE's scientific research. The goal is to provide educators with the tools to sharpen their science and math foundations and apply these tools to their classroom practice. Funds will be provided to pay for teachers' stipends, travel, housing and subsidize laboratory scientists' time for this activity ($2,921,000).

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Physics Research	143,592	145,835	159,650	+13,815	+9.5%
High Energy Technology	65,536	69,056	67,540	-1,516	-2.2%
Total, Research and Technology	209,128	214,891	227,190	+12,299	+5.7%

Detailed Program Justification

(dollars in thousands)

	FY 1998	FY 1999	FY 2000
Physics Research			
■ **Fermilab:** In FY 2000 the experimental physics research groups at Fermilab will be working on completing and bringing into operation the upgraded CDF and D-Zero facilities, completing a fixed target run, analyzing data from recent experimental data taking runs, and preparing for future experiments including participation in the CMS detector for LHC. The theoretical research group and the theoretical astrophysics group will be working on a variety of theoretical topics.	10,415	8,826	9,240
■ **SLAC:** The experimental physics research groups at SLAC will concentrate their efforts in FY 2000 on the physics analysis and interpretation of the large amounts of data taken with the SLC Large Detector (SLD) detector in prior years, and on early data-taking with the recently commissioned BaBar detector facility and B-factory. Some physics research will also be done in a fixed target experiment studying parity violation, and with the CLEO detector at the Cornell Electron Storage Ring (CESR) facility at Cornell. The theoretical physics group will continue to emphasize topics related to the SLD, BaBar, and Next Linear Collider (NLC) research programs as well as tests of the Standard Model and Quantum ChromoDynamics (QCD).	11,411	12,027	12,441
■ **BNL:** In FY 2000, the BNL experimental physics research groups will be working on experiments at the BNL-AGS involving precision measurements of the muon magnet moment, and rare decays of the K meson; on the Fermilab collider experiment D-Zero probing the high energy frontier; and on the U.S. effort on the Large Hadron Collider ATLAS detector. The Theoretical physics research groups will be working on a number of topics.	7,662	7,690	8,226

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **LBNL:** In FY 2000, LBNL researchers will be analyzing data recently taken at the collider detectors and at fixed target experiments at Fermilab, and will be preparing for studies of B-Bbar decays using the BaBar detector on the B-factory at SLAC. The researchers will also be working on supernova measurements to establish values for cosmological parameters. Recent results indicate the universe may be expanding at an increasing rate. The Particle Data Group at LBNL continues as an international clearinghouse for particle physics information.	10,375	10,498	11,033
■ **ANL:** The experimental high energy physics group will continue collaborating in research on the CDF at Fermilab, and ZEUS at the DESY/HERA facility in Hamburg, Germany. They also will be working on the fabrication of two major new detector facilities: the ATLAS detector for future use at CERN's LHC facility, and the MINOS detector at the Soudan site in Minnesota. The MINOS detector is part of the NuMI project and will use a neutrino beam from Fermilab. The theoretical physics group will continue their research in formal theory, collider phenomenology, and lattice gauge calculations.	5,489	5,465	5,465
■ **Universities and Other Laboratories:** The University Program consists of groups at 100 universities doing experiments (77 universities) and theory (75 universities). These university groups plan, build, execute, analyze and publish results of experiments, train graduate students and post-docs; and provide theoretical concepts, simulations and calculations of physical processes involved in high energy physics. Provides support for research scientists at LANL, LLNL, ORNL, and PNNL. This University and small laboratory (LANL, LLNL, ORNL, PNNL) based research activity is described in more detail below. The recent HEPAP Subpanel (Gilman), recommended that the level of funding for the university based portion of the program be substantially increased over inflation over the next two year period. The funding detailed below includes funding for 3.5 percent over inflation providing more than half of the recommended first year increase. These increases are aimed at improving the research capabilities and operational effectiveness of these (primarily) university based research groups.			

	FY 1998	FY 1999	FY 2000
	(dollars in thousands)		
▸ **University and other laboratory based Research using Fermilab:** Some 55 DOE-funded universities participate in large international collaborations doing experiments at Fermilab. LLNL is also involved in the MINOS project. These experiments involve the CDF and D-Zero collider detectors, and the KTEV, FOCUS, MINOS, DONUT, and HYPER-CP experiments using external beams of kaons, photons, neutrinos and hyperons. Other experiments are performed in the antiproton accumulator. These universities help to fabricate the detectors, plan and execute the experiments, analyze data and publish the results. The participation has been and is expected to remain about constant, as fixed target 800 GeV experiments diminish and CMS, MINOS, and BTeV related activities increase.	24,905	25,170	26,940
▸ **University and other laboratory based Research using SLAC:** Some 27 DOE–funded universities participate in large international collaborations doing experiments at SLAC. LLNL is also involved in the BaBar detector project. The experiments involve the SLD and BaBar detectors, and other smaller detectors for fixed target experiments. These universities help to build the detectors, plan and carry out experiments, analyze the data and publish the results. The participation has been and is expected to remain about constant, as SLD diminishes, BaBar flourishes, and work on a future large linear collider continues.	9,960	10,360	11,400
▸ **University based Research using BNL:** Some 10 DOE-funded universities participate in collaborative experiments at BNL. These experiments involve fixed targets and kaon or pion beams, colliding beams of protons (RHIC-SPIN) or nuclei (PHOBOS) at RHIC, and external storage rings measuring the muon anomalous magnetic moment to high precision. This participation has decreased significantly due to the phasing out of most of the AGS High Energy Physics program.	3,980	2,960	2,070

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ **University based Research using the Cornell Electron Storage Rings:** Some 11 university High Energy Physics groups with DOE funding participate in the electron-positron colliding beam experiments at Cornell's CESR facility utilizing the collaboratively built CLEO detector. They help to plan, build, execute, analyze and publish the experiments. This participation has been decreasing, as some groups move to BaBar at SLAC.	4,980	4,440	4,145
▸ **University and other laboratory based Research not using accelerators:** Some 28 DOE-funded universities are involved in High Energy Physics experiments not utilizing accelerators. LANL, LLNL and PNNL are also involved in non-accelerator experiments. These experiments, which are primarily in the areas of astrophysics and cosmology, include MACRO (Italy), Super-Kamiokande (Japan), SNO (Canada), CHOOZ (France), SOUDAN (Minnesota), CDMS (Stanford), GRANITE (Mt. Hopkins, Arizona), Palo Verde (Arizona) and AMS (Space Station). They help build the detectors, plan, execute, analyze and publish the results. This participation has increased and is expected to increase further due to the newly emerging interest and opportunities in astrophysics and cosmology, such as GLAST, AUGER and CDMS (Soudan). The funding includes an increase of $1,800,000 for the fabrication of underground detectors such as those listed above. The allocation of these funds will be decided on the basis of a peer review process which is presently underway.	12,950	15,300	18,115
▸ **University and other laboratory Theoretical Studies:** Some 75 universities with DOE funding participate in research in theoretical high energy physics. Theoretical studies at LANL are also included here. This effort is expected to remain about constant. They provide theoretical ideas, concepts, calculations and simulations of physical processes in high energy physics.	18,920	19,250	20,720

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ **University based Research using Foreign Labs:** Universities funded by the DOE are doing experiments with international collaborations using facilities at foreign accelerator labs. Some 45 universities are conducting experiments at CERN (Switzerland), 11 at DESY (Germany), 10 at KEK (Japan), 1 at IHEP (Russia), 1 at BINP (Russia), and 2 at Beijing (China). They help to fabricate the detectors and experimental apparatus, plan and execute the experiments, analyze the data and publish the results. The participation has increased and is expected to increase further with the participation in the ATLAS and CMS detectors at CERN's LHC. The funding includes an increase of $1,000,000 to address technical infrastructure needs, such as technical staff and computers, related to research operations at foreign laboratories.	20,925	22,700	26,930
▸ **Other University and other laboratory based Research activities:** A new focussed program in Detector R&D, recommended by the HEPAP Subpanel, was started modestly in FY 1999, will be continued and expanded slightly ($1,000,000). The Outstanding Junior Investigator program, which is intended to identify and provide support for highly promising investigators at an early stage in their careers, will continue at a level of about $400,000 in new awards per year. A new educational program, Quark-Net, aimed at involving high school students and teachers in high energy physics research, will be started in FY 1999 and will continue at $250,000. The accelerator and beamline shielding studies carried out at ORNL are included here. Funding of conferences, studies, and workshops is also included here. The funding includes an increase of $500,000 to increase the capability of the computer network link to CERN and an increase of $750,000 for anticipated but unknown needs or opportunities which is not yet allocated.	1,620	1,149	2,925
Total, Universities and Other Laboratories	98,240	101,329	113,245
Total, Physics Research	143,592	145,835	159,650

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
High Energy Technology			
■ **Fermilab:**			
▸ **Accelerator R&D:** Activities in FY 2000 include design of an improved proton source; design of an electron cooling system to improve antiproton beam quality: construction of a large-scale experiment to test the concept of ionization cooling, which is critical for any future muon collider; R&D on superconducting magnets and other components for future 100 TeV proton colliders; and tests of accelerating electrons with plasma wake-fields driven by intense electron beams. Muon collider R&D, with a high priority in the National High Energy Physics program, will increase in FY 2000. The proposed funding provides an approximately constant level of effort, except for the increase to permit the critical muon collider experiment to proceed.	9,221	7,670	8,670
▸ **Experimental Facilities R&D:** Activities in FY 2000 include: R&D on the feasibility of reducing the cell size in the CDF detector wire chamber to accommodate the higher track density that will result from increasing the Tevatron collider event rate; developing scintillating fibers for the D–Zero detector that are capable of withstanding the increased radiation level resulting from the increased collision rates; R&D on radiation-hard materials such as diamond and silicon carbide to replace silicon micro strip detectors at high collision rates; R&D on specialized electronics for high event rates in numerous, high-density data channels; and developing parallel computing configurations, high speed networks, and high-capacity data storage systems for high data rates. The proposed funding provides a slightly decreasing level of effort.	8,700	6,670	6,670
Total, Fermilab	17,921	14,340	15,340

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **SLAC:**			
▸ **Accelerator R&D:** Activities in FY 2000 include R&D to explore new concepts in accelerator physics in support of design of future linear colliders. The R&D on the design for a linear collider to operate with TeV scale center of mass energy will be reduced to $12,000,000 in FY 2000. Relevant areas are high powered radio frequency systems, accelerator structures, controls and instrumentation, and advanced beam optics. This R&D and design activity is being done in the context of an international collaboration. R&D in support of the B-factory, commissioned in FY 1999, will continue at a significant level to ensure a strong luminosity performance in the initial data run for physics research. The R&D programs in generic collider R&D will continue, and the program in advanced accelerator physics looking at the use of lasers, plasmas, and ultra high frequency radio frequency systems, will be given slightly increased priority.	14,651	16,500	11,900
▸ **Experimental Facilities R&D:** In FY 2000, the focus will be on instrumentation for physics studies in the center of mass collision energy range of 50 GeV to 5,000 GeV. This will include work to support and improve performance of BaBar, the newly operating B-factory detector, and an expanded program of R&D, consistent with the recommendations of the HEPAP Subpanel, on developing preliminary designs for a detector to operate with a new electron-positron linear collider operating at the TeV center of mass energy scale.	1,545	2,500	2,900
Total, SLAC	16,196	19,000	14,800

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **BNL:**			
▸ **Accelerator R&D:** Activities in FY 2000 will include, R&D on new methods of particle acceleration such as laser acceleration and Free Electron Laser (FEL) accelerators, primarily using the excellent capabilities of the BNL Accelerator Test Facility. R&D on the muon collider concept will be expanded and will include design work on key system components including the high field solenoid and the dipole magnets. In the BNL superconductor test facility the characterization of new high critical temperature superconductors as well as their special requirements for magnet fabrication should be better understood. With the transfer of the AGS to the Nuclear Physics program during FY 1999, Accelerator R&D in support of the AGS is being brought to an orderly close.	5,570	5,045	5,155
▸ **Experimental Facilities R&D:** In FY 2000, semiconductor drift photo diodes for detection of photons of energies as low as 50 eV will be designed and produced. Development of radiation hardened monolithic electronics for a number of experiments will continue. Development of lead-wolfrate crystals with improved light output will continue. Testing of the modules that constitute the ATLAS barrel calorimeters will begin.	3,065	1,075	1,075
Total, BNL	8,635	6,120	6,230
■ **LBNL:**			
▸ **Accelerator R&D:** LBNL is a major contributor to accelerator and superconducting magnet R&D for advanced accelerator concepts, including the muon collider and the next linear collider. Development of these concepts is needed to advance the energy and luminosity frontiers to better understand the structure of matter. LBNL has a major role in designing, building, and testing the Low Energy Ring at the B-factory. In FY 1999, the B-factory will be fully commissioned. In FY 2000, preparations for muon cooling experiments, needed to confirm the practicality of a muon collider, will begin at Fermilab, using components developed at LBNL. The high-gradient, all-optical, laser-plasma wakefield accelerator at LBNL will begin accelerating electron bunches.	6,935	6,905	7,565

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ **Experimental Facilities R&D:** LBNL leads in providing custom state-of-the-art electronics, such as silicon vertex detectors, integrated circuit (IC) systems, and other components for high-energy particle detectors such as BaBar at the B-factory and the upgrades to CDF and D–Zero for the next, higher luminosity, runs at Fermilab. LBNL is also involved in developing computer programs for experimental data taking and analysis. In FY 2000, work will continue on large format CCDs and high-resolution imaging systems, plus the production and testing of IC systems.	2,620	2,670	2,670
Total, LBNL	9,555	9,575	10,235
■ **ANL:**			
▸ **ANL Accelerator R&D:** R&D will continue on the acceleration of electrons using structures with plasmas or structures made of dielectric materials called wakefield accelerators. Using this new technique, accelerating gradients at one-third of conventional levels have been reached. Thus there is optimism that the much higher gradient predicted by theory can be achieved. Planning will be underway for an upgraded experimental facility which could generate much higher gradients. In addition, work will be undertaken on muon collider R&D as recommended by the HEPAP Subpanel.	1,135	1,130	1,305
▸ **Experimental Facilities R&D:** In FY 2000 work will be underway on the MINOS detector, the ATLAS detector for the LHC, and a possible upgrade of the ZEUS detector at DESY.	900	920	920
Total, ANL	2,035	2,050	2,225

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **Universities, Other Laboratories, and Other Contractors:**			
▸ **University Program:** The funding will provide for a program of high priority technology R&D relevant to the development of particle accelerators. The R&D is aimed at breakthrough technologies; superconductors for high-field magnets; laser and collective-effect accelerator techniques; novel, high-power radio frequency generators; theoretical studies in particle beam physics, including the non-linear dynamics of particle beams; and at lowering the cost and improving the performance of future experiments and facilities. This element also includes the portion of the increased funding for R&D on future facility concepts as summarized in the table below which has not yet been allocated. Discussions and peer reviews are underway to design an optimum overall program and to identify and fund key activities. In FY 1998 $770,000 was transferred to the STTR program. Additional funding for the SBIR program is contained in the Facility Operations subprogram.	11,194	17,971	18,710
Total, High Energy Technology	65,536	69,056	67,540
Total, Research and Technology, ...	209,128	214,891	227,190

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
■ **Physics Research**	
▸ An increase in the base funding for the university program as recommended by the HEPAP.	+6,475
▸ An increase in the funding for the fabrication of non accelerator experiments as recommended by the HEPAP.	+1,800
▸ An increase to initiate an expanded program of detector R&D as recommended by the HEPAP.	+600
▸ An increase to provide for additional R&D to address the computing and networking needs of the new generation of detectors.	+1,500
▸ Initiation of an education program at National Laboratories.	+2,921

	FY 2000 vs. FY 1999 ($000)
▸ An increase in the funds held for allocation pending completion of planning and peer review activities.	+519
Total, Physics Research	+13,815
■ **High Energy Technology**	
▸ An increase in the funding for muon collider R&D at Fermilab	+1,000
▸ A decrease in the funding for NLC R&D at SLAC.	-5,000
▸ An increase in other Technology R&D at SLAC.	+800
▸ An increase in the funding for muon collider R&D at BNL.	+980
▸ Termination of the program of accelerator R&D at the AGS.	-870
▸ An increase in the funding of muon collider R&D at LBNL.	+660
▸ An increase in the funding for muon collider R&D at ANL.	+175
▸ An increase in the base funding for the advanced accelerator R&D program.	+620
▸ An increase in the funding held for allocation pending completion of planning and peer review activities.	+119
Total, High Energy Technology	-1,516
Total Funding Change, Research and Technology	+12,299

The following table summarizes the above changes for possible future HEP facilities:

	(dollars in millions)		
	FY 1998	FY 1999	FY 2000
Next Linear Collider	10.0	17.0	12.0
Muon-Muon Collider	4.5	5.5	8.2
Very Large Hadron Collider	2.5	3.0	3.0

Facility Operations

Mission Supporting Goals and Objectives

The Facility Operations subprogram includes the provision and operation of the large accelerator and detector facilities which are the essential tools that enable scientists in university and laboratory based research groups to perform experimental research in high energy physics. This subprogram includes funding for the operation and maintenance of the national laboratory research facilities including accelerators, colliders, secondary beam lines, detector facilities for experiments, experimental areas, computing, and computing networking facilities. It includes the costs of detector and accelerator components, personnel, electric power, expendable supplies, replacement parts and subsystems, inventories and, at Fermilab and SLAC, waste management activities. General Plant Projects (GPP) funding is provided for minor new construction, other capital alterations and additions, and for buildings and utility systems. Landlord General Purpose Equipment (GPE), and GPP funding for Lawrence Berkeley National Laboratory, Fermi National Accelerator Laboratory and Stanford Linear Accelerator Center are also included. Accelerator Improvement Projects (AIP) funding support for additions and modifications to accelerator facilities which are supported by the High Energy Physics research program is also included.

The principal objective of the Facility Operations subprogram is to maximize the quantity and quality of data collected for approved experiments being conducted at the High Energy Physics facilities. The ultimate measure for success in the Facility Operations subprogram is whether the research scientists have data of sufficient quantity and quality to do their planned measurements or to discover new phenomena. The quality of the data is dependent on the accelerator and detector capabilities, and on the degree to which those capabilities are achieved during a particular operating period. The quantity of the data relates primarily to the beam intensity, the length of the operating periods, and the operational availability of the accelerator and detector facilities.

Performance Measures

- Progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on achieving luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.
- High Energy Physics will begin operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab.

Planned Accelerator Operations

(in weeks)

	FY 1998	FY 1999	FY 2000
Fermilab	13	38	29
SLAC	33	42	39
BNL	12	14	8

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
Fermi National Accelerator Laboratory	191,195	210,145	212,743	+2,598	+1.2%
Stanford Linear Accelerator Center	107,745	111,290	118,290	+7,000	+6.3%
Brookhaven National Laboratory	59,367	42,882	5,347	-37,535	-87.5%
Universities and Other Laboratories	10,345	25,408	29,910	+4,502	+17.7%
Large Hadron Collider	35,000	65,000	70,000	+5,000	+7.7%
Waste Management	4,960	4,910	4,910	0	0.0%
Total, Facility Operations	408,612	459,635	441,200	-18,435	-4.0%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

Fermilab

Provides support for operation, maintenance, improvement, and enhancement of the Tevatron accelerator and detector complex. This complex includes the Tevatron, which can operate in a collider mode with protons and anti-protons, or in a fixed target mode with protons only; the new Main Injector which will be completed and commissioned in FY 1999; the Booster; the Linac; and the Anti-proton Source and Accumulator. The Tevatron collider and the 800 GeV fixed target modes are mutually exclusive; however, a fixed target program at 120 GeV using the new Main Injector is possible in parallel with Tevatron collider operation. This complex also includes the two large colliding beams detectors – CDF and D-Zero – and a number of fixed target experiments in the external beams areas.

■ **Accelerator Operation:** In FY 2000, the upgraded Tevatron complex will be operated for about 6 weeks ending a fixed target run begun in FY 1999. This will be followed by 8 weeks of commissioning of the Main Injector and 15 weeks of operation of the Tevatron in collider mode with the higher luminosity available from the newly completed Main Injector. The funds requested will provide for the operation of the Tevatron, the Main Injector, the Booster, the Linac and the antiproton source as needed. The reduction in capital expenditures resulting from the completion of the CDF and D-Zero detector upgrade projects is partially offset by the planned increase for the MINOS Detector.	116,910	126,535	126,333

	FY 1998	FY 1999	FY 2000
	(dollars in thousands)		
■ **Experimental Facility Operations:** In FY 2000, the upgrades of the CDF and the D-Zero detectors will be completed and the upgraded detectors will be brought into operation. In addition, the funding will support the active experiments in the completion of the fixed target run. The funding will also be used to provide the computing resources needed for the analysis of existing data and the planning and design of future experiments.	74,285	83,610	86,410
Total, Fermilab	191,195	210,145	212,743

Tevatron Operation

	FY 1998	FY 1999	FY 2000
	(in weeks)		
Fixed Target	0 [a]	22	6
Collider	0 [a]	0	15
Commissioning	13	16	8
Total, Tevatron Operation	13	38	29

SLAC

Provides for the operation, maintenance, improvement and enhancement of the accelerator and detector complex on the SLAC site. The accelerators include the electron linac and the SLC, and to these is being added the B-factory completed in FY 1999. The detector facilities include the SLD, the End Station A experimental set-ups, and BaBar, the detector which is being constructed for use with the B-factory. Also provides for maintenance of the laboratory physical plant.

[a] Operation of the Tevatron in collider or fixed target mode in FY 1998 is precluded by the long shutdown needed for completion of the Fermilab Main Injector project.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **Accelerator Operation:** Accelerator operations at SLAC in FY 2000 will concentrate heavily on about 9 months of strong utilization of the newly completed asymmetric B-factory colliding beam storage rings in order to maximize the data collected by the BaBar detector facility. The linac will serve primarily as the injector of positrons and electrons to the B-factory storage rings during this time, although a 5 month parasitic run of a fixed target experiment at the full linac energy is also planned. Includes initial Major Item of Equipment (MIE) funding ($3,000,000) for the fabrication of a portion of the Gamma-ray Large Area Space Telescope (GLAST) project. GLAST, a high sensitivity space based instrument for the study of high energy gamma rays, is planned as a joint DOE-NASA project and has the potential for significant contributions from a number of foreign collaborators. SLAC is the lead laboratory for the DOE portion of the project. Total estimated cost is subject to further negotiations with NASA and potential foreign collaborators.	82,228	79,300	84,500
■ **Experimental Facility Operations:** Experimental facility operations will emphasize running the newly completed BaBar detector facility, which will be the priority research program at SLAC in FY 2000. The End Station A complex will also be operated during the fixed target run.	25,517	31,990	33,790
Total, SLAC	107,745	111,290	118,290

SLAC Operation

	(in weeks)		
	FY 1998	FY 1999	FY 2000
SLC	16	0	0
Fixed Target	0	10	15[a]
B-factory Commissioning	17	16	0
B-factory Operation	0	16	39
Total, SLAC Operation	33	42	39

[a] Fixed Target operation in parallel with B-factory operation.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
BNL			
Provides support for the operation, maintenance, improvement, and enhancement of the accelerator and detector complex on the BNL site. The principal facility is the AGS and its complement of experimental set ups. The AGS was transferred to the Nuclear Physics program during the 3rd quarter of FY 1999 to be operated as part of the RHIC facility. In FY 2000, the AGS operation for the HEP program will be on an incremental cost basis.			
■ **Accelerator Operation:** Operation activities covered under this budget category include the incremental cost of running the AGS complex for HEP. Operation for High Energy Physics in FY 2000 will be a eight week run for the muon magnetic moment experiment. Includes, in FY 1998 and FY 1999, but not FY 2000 landlord GPP and GPE funding..	38,332	29,672	3,047
■ **Experimental Facility Operations:** Provides for eight weeks of operation of the muon magnetic moment experiment and general support activities in the experimental areas.	21,035	13,210	2,300
Total, BNL	59,367	42,882	5,347

AGS Operation

	(in weeks)		
	FY 1998	FY 1999	FY 2000
AGS Operation for HEP	12	14	8

Universities and Other Labs			
Provides for capital equipment funding at ANL, LBNL, some smaller DOE labs, and for university based researchers. Provides landlord GPP and GPE for LBNL beginning in FY 2000. Includes $14,735,000 in FY 1999 and $15,015,000 in FY 2000 for the SBIR and STTR programs. Provides for certain computer networking expenses.	10,345	25,408	29,910

Large Hadron Collider

- In FY 1998 and FY 1999, funding was used for: R&D and measurement/testing on superconducting materials, cable, and wire; calculations and R&D on accelerator physics issues regarding the design, instrumentation, and prototypes of the magnets and RF accelerating cavities for the colliding beam intersection regions. Activities on the detectors will include R&D and prototype development of subsystems such as

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
tracking chambers, calorimeters, and data acquisition electronics.			

The LHC work is being performed at various locations including 4 major DOE labs and more than 55 U.S. universities.

LHC Accelerator and Detector Funding Summary

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
Facility Operations			
LHC			
Accelerator Systems			
Operating Expenses	4,315	7,070	600
Capital Equipment	9,685	8,330	19,500
Total, Accelerator Systems	14,000	15,400	20,100
Procurement from Industry	0	14,340	11,100
ATLAS Detector			
Operating Expenses	4,416	8,440	4,900
Capital Equipment	5,634	2,760	10,600
Total, ATLAS Detector	10,050	11,200	15,500
CMS Detector			
Operating Expenses	5,650	14,550	14,110
Capital Equipment	5,300	9,510	9,190
Total, CMS Detector	10,950	24,060	23,300
Total, LHC	35,000	65,000	70,000

	FY 1998	FY 1999	FY 2000
▸ **Accelerator Systems:** In FY 2000, funding will support continuation of the production of interaction region quadrupole magnets, feedboxes, and absorbers; production of RF region dipoles; superconducting cable testing and support; and accelerator physics design studies.	14,000	15,400	20,100
▸ **Procurement from Industry:** Funding will support reimbursement to CERN for purchases from U.S. industry including superconducting wire, cable, and cable insulation materials.	0	14,340	11,100

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ **ATLAS Detector:** In FY 2000, funding will support the production of silicon strips, transition radiation tracker (TRT) modules, barrel cryostat and feedthroughs, front end electronics for the liquid argon calorimeter, the extended barrel tile calorimeter and electronics, the monitored drift tube muon chambers and electronics, and the alignment system for the muon spectrometer. The funding will also provide for advanced prototypes: the readout drivers (RODs) for the silicon and liquid argon systems, the TRT electronics, the electronic system for the liquid argon calorimeter. The R&D will be concluding for the pixel detectors while continuing for the trigger and data acquisition system.	10,050	11,200	15,500
▸ **CMS Detector:** In FY 2000, funding will support work on three of the subsystems in CMS. The endcap muon system will have set up the cathode strip chamber factory in FY 1999, and will be in full production. The hadron calorimeter system will have completed the two preproduction prototypes in FY 1999 and be in full production of copper absorber and the optics. The magnet system will complete the procurement of the majority of the items for the barrel and endcap steel flux return and the coil vacuum tank. The electromagnetic calorimeter subsystem will include procurement of front end transducers and electronics. The trigger/data acquisition and forward pixel subsystems will still be in an engineering phase.	10,950	24,060	23,300
Total, LHC	35,000	65,000	70,000

Waste Management

■ Continues the pilot program concerning packaging, shipment and disposition of hazardous, radioactive or mixed waste generated in the course of normal operations at Fermilab and SLAC. This pilot program is intended to evaluate opportunities to reduce the volume of newly generated waste and its associated management and disposal costs..	4,960	4,910	4,910
Total, Facility Operations	408,612	459,635	441,200

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
■ **Fermilab**	
▸ An increase to support full operation of the facility.	+5,600
▸ An increase in GPP.	+999
▸ A decrease in equipment funding reflecting the completion of the CDF and D-Zero detectors offset by increase in the funding for the NuMI/Minos detector.	-4,001
Total, Fermilab	+2,598
■ **Stanford Linear Accelerator Center**	
▸ An increase to support full utilization of the B-factory.	+5,300
▸ An increase in AIP and GPP.	+1,700
Total, Stanford Linear Accelerator Center	+7,000
■ **Brookhaven National Laboratory**	
▸ A decrease reflecting the transfer of the AGS to the NP program.	-28,175
▸ A decrease reflecting the transfer of landlord responsibilities (GPP, GPE) to NP.	-9,360
Total, Brookhaven National Laboratory	-37,535
■ **Universities/Other**	
▸ An increase reflecting primarily the addition of the landlord responsibilities (GPP, GPE) at LBNL to HEP.	+4,502
■ **Large Hadron Collider**	
▸ An increase to follow the agreed profile.	+5,000
Total Funding Change, Facility Operations	-18,435

Construction

Mission Supporting Goals and Objectives

This provides for the construction of major new facilities needed to meet the overall objectives of the High Energy Physics Program.

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
Construction	50,850	21,000	28,700	+7,700	+36.7%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **Fermilab Main Injector Project:** This project provides for a new accelerator to replace the injector accelerator for the Tevatron complex. The present injector for the Tevatron is the original Fermilab main ring which is less than fully adequate and nearing the end of its useful lifetime. The accelerator will be commissioned and the project completed during FY 1999.	30,950	0	0
■ **SLAC Master Substation Upgrade:** This project provides for an upgrade and reconfiguration of the main electric power substation on the SLAC site. Obsolete (and hazardous) switch gear will be replaced and load balancing will be implemented thus extending the useful life of the existing main 230 kv transformers. Procurement of long lead switch gear items was initiated in FY 1997, and the project will be completed by the end of FY 1998.	9,400	0	0
■ **Neutrinos at the Main Injector (NuMI):** This project provides for the construction of new facilities at Fermilab and at the Soudan Underground Laboratory in Soudan, Minnesota which are especially designed for the study of the properties of the neutrino and in particular to search for the neutrino oscillations. The FY 2000 funding is for continued detailed design and initiation of construction of conventional facilities and technical components.	5,500	14,300	22,000

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **C-Zero Area Experimental Hall:** This project provides for the construction of a new experimental hall at the C-Zero location on the Fermilab Tevatron ring. This will be used to house modest sized collider and fixed target experiments in a new experimental program being planned at Fermilab. This project will be completed in FY 1999.	5,000	0	0
■ **Wilson Hall Safety Improvement Project (Fermilab):** This project provides for urgently needed rehabilitation of the main structural elements of Wilson Hall, and for urgently needed rehabilitation of windows, plumbing, the roof and the exterior of the building.	0	6,700	4,700
■ **SLAC Research Office Building:** This project provides urgently needed office space for the substantial expansion of visiting scientists, or “users”, which will occur when the B-factory becomes operational. The visiting user population is projected to increase from 200 visitors per year to 1,100 visitors per year. The new building will provide about 30,000 square feet and will be completed in FY 2001.	0	0	2,000
Total, Construction	50,850	21,000	28,700

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
■ Continuation of the Wilson Hall Safety Improvement Project at Fermilab.	-2,000
■ Continuation of the Fermilab NuMI project.	+7,700
■ Initiation of the Research Office Building.	+2,000
Total Funding Change, Construction	+7,700

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1998	FY 1999	FY 2000 Request	$ Change	% Change
General Plant Projects	13,455	14,841	12,985	-1,856	-12.5%
Accelerator Improvement Projects	5,963	10,186	10,885	+699	+6.9%
Capital Equipment	93,539	76,363	90,315	+13,952	+18.3%
Total, Capital Operating Expense	112,957	101,390	114,185	+12,795	+12.6%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp- riations	FY 1998	FY 1999	FY 2000 Request	Unapprop- riated Balance
92-G-302 Fermilab Main Injector	229,600	198,650	30,950	0	0	0
97-G-303 SLAC Master Substation Upgrade	12,400	3,000	9,400	0	0	0
98-G-304 Neutrinos at the Main Injector	76,200	0	5,500	14,300	22,000	34,400
98-G-305 C-Zero Area Experimental Hall	5,000	0	5,000	0	0	0
99-G-306 Wilson Hall Safety Improvements . .	15,600	0	0	6,700	4,700	4,200
00-G-307 SLAC Office Building	7,200	0	0	0	2,000	5,200
Total Construction		201,650	50,850	21,000	28,700	43,800

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1998	FY 1999	FY 2000 Request	Accept-ance Date
D-Zero Upgrade	55,270	28,467	14,525	9,555	2,723	FY 2000
CDF Upgrade	54,957	27,957	13,525	9,555	3,920	FY 2000
B-factory detector (BaBar)[a]	68,000	43,000	21,700	3,300	0	FY 1999
Antimatter in Space	3,192	2,992	200	0	0	FY 1998
Super-Kamiokande	3,584	3,053	531	0	0	FY 1998
Large Hadron Collider — Machine [a]	90,615	0	11,485	8,330	19,500	FY 2005
Large Hadron Collider — ATLAS Detector [a]	63,424	0	5,634	2,760	10,600	FY 2005
Large Hadron Collider — CMS Detector [a]	55,950	0	5,300	9,510	9,190	FY 2005
MINOS	45,000	0	0	2,000	5,868	FY 2002
GLAST[b]	N/A	0	0	0	3,000	N/A
Total, Major Items of Equipment		105,469	72,900	45,010	54,801	

[a] The funding for the B-factory detector reflects cost savings of about $20,000,000 resulting from contributions of components and subsystems by non-U.S. collaborating institutions.

[b] Total estimated cost is subject to further negotiations with NASA and potential foreign collaborators.

98-G-304, Neutrinos at the Main Injector (NuMI), Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 1999 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

Significant Changes

Total Estimated Cost and Total Project Cost have been adjusted due to changes in the construction profile.

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1998 Budget Request *(A-E and technical design only)*	1Q '98	4Q '98	NA	NA	5,500	6,300
FY 1999 Budget Request *(Preliminary Estimate)*	— " —	3Q '99	1Q '99	4Q '02	75,800	135,300
| FY 2000 Budget Request	3Q '98	2Q '00	3Q '99	2Q '03	76,200	136,100

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Design			
| 1998	5,500	5,500	1,140
Construction			
| 1999	14,300	14,300	8,360
| 2000	22,000	22,000	26,300
| 2001	23,000	23,000	27,000
| 2002	11,400	11,400	11,900
| 2003	0	0	1,500

3. Project Description, Justification and Scope

The project provides for the design, engineering and construction of new experimental facilities at Fermi National Accelerator Laboratory in Batavia, Illinois and at the Soudan Underground Laboratory at Soudan, Minnesota. The project is called NuMI which stands for Neutrinos at the Main Injector. The purpose of the project is to provide facilities which will be used by particle physicists to study the properties of neutrinos, which are fundamental elementary particles. In the Standard Model of elementary particle physics there are three types of neutrinos which are postulated to be massless and to date, no direct experimental observation of neutrino mass has been made. However, there are compelling hints from experiments which study neutrinos produced in the sun and in the earth's atmosphere that indicate that if neutrinos were capable of changing their type it could provide a credible explanation for observed neutrino deficits in these experiments.

The primary element of the project is a high flux beam of neutrinos in the energy range of 1 to 40 GeV. The technical components required to produce such a beam will be located on the southwest side of the Fermilab site, tangent to the new Main Injector accelerator at the MI-60 extraction region. The beam components will be installed in a tunnel of approximately 1 km in length and 6.5 m diameter. The beam is aimed at two detectors (MINOS) which will be constructed in experimental halls located along the trajectory of the neutrino beam. One such detector will be located on the Fermilab site, while a second will be located in the Soudan Underground Laboratory. Two similar detectors in the same neutrino beam and separated by a large distance are an essential feature of the experimental plan.

The experiments which are being designed to use these facilities will be able to search for neutrino oscillations occurring in an accelerator produced neutrino beam and hence determine if neutrinos do have mass. Fermilab is the only operational high energy physics facility in the U.S. with sufficiently high energy to produce neutrinos which have enough energy to produce tau leptons. This gives Fermilab the unique opportunity to search for neutrino oscillations occurring between the muon and the tau neutrino. Additionally, the NuMI facility is designed to accommodate future enhancements to the physics program that could push the search for neutrino mass well beyond the initial goals established for this project.

4. Details of Cost Estimate [a]

(dollars in thousands)

	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	7,150	7,720
Design Management costs (0.0% of TEC)	10	8
Project Management costs (0.0% of TEC)	20	22
Total, Engineering design inspection and administration of construction costs (9.4% of TEC)	7,180	7,750
Construction Phase		
Buildings	8,320	2,880
Special Equipment	10,120	10,270
Other Structures	30,960	38,690
Construction Management (6.0% of TEC)	4,590	540
Project Management (2.8% of TEC)	2,170	1,620
Total, Construction Costs	56,160	54,000
Contingencies		
Design Phase (2.8% of TEC)	2,172	not available
Construction Phase (14.0% of TEC)	10,688	not available
Total, Contingencies (16.8% of TEC)	12,860	14,050
Total, Line Item Cost (TEC)	76,200	75,800

5. Method of Performance

Design of the facilities will be by the operating contractor and subcontractor as appropriate. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

[a] The annual escalation rates assumed for FY 1996 through FY 2002 are 2.5, 2.8, 3.0, 3.1, 3.3, 3.4, and 3.4 percent respectively.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1998	FY 1999	FY 2000	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC	0	1,140	8,360	26,300	40,400	76,200
Other Project Costs						
Capital equipment [a]	0	0	2,000	5,868	36,357	44,225
R&D necessary to complete construction [b]	450	810	40	0	0	1,300
Conceptual design cost [c]	630	200	0	0	0	830
Other project-related costs [d]	0	1,520	960	7,632	3,433	13,545
Total, Other Project Costs	1,080	2,530	3,000	13,500	39,790	59,900
Total Project Cost (TPC)	1,080	3,670	11,360	39,800	80,190	136,100

[a] Costs to fabricate the near detector at Fermilab and the far detector at Soudan. Includes systems and structures for both near detector and far detector, active detector elements, electronics, data acquisition, and passive detector material.

[b] This provides for project conceptual design activities, for design and development of new components, and for the fabrication and testing of prototypes. R&D on all elements of the project to optimize performance and minimize costs will continue through early stages of the project. Specifically included are development of active detectors and engineering design of the passive detector material. Both small and large scale prototypes will be fabricated and tested using R&D operating funds.

[c] Includes operating costs for development of conceptual design and scope definition for the NuMI facility. Also includes costs for NEPA documentation, to develop an Environmental Assessment, including field tests and measurements at the proposed construction location.

[d] Include funding required to complete the construction and outfitting of the Soudan Laboratory for the new far detector by the University of Minnesota.

7. Related Annual Funding Requirements

	(FY 2003 dollars in thousands) Current Estimate	Previous Estimate
Annual facility operating costs [a]	500	NA
Utility costs (estimate based on FY 1997 rate structure) [b]	500	NA
Total related annual funding	1,000	NA
Total operating costs *(operating from FY 2003 through FY 2007)*	5,000	NA

[a] Including personnel and M&S costs (exclusive of utility costs), for operation, maintenance, and repair of the NuMI facility.

[b] Including incremental power costs for delivering 120 GeV protons to the NuMI facility during Tevatron collider operations, and utility costs for operation of the NuMI facilities, which will begin beyond FY 2002.

99-G-306, Wilson Hall Safety Improvements Project, Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 1999 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1999 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800
FY 2000 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
1999	6,700	6,700	1,690
2000	4,700	4,700	6,340
2001	4,200	4,200	6,990
2002	0	0	580

3. Project Description, Justification and Scope

Wilson Hall, constructed in 1972, is the central laboratory facility for the Fermilab site. It is a 17 story reinforced concrete building with a 16 story atrium. The great majority of its area is devoted to office space. In addition, the building contains the cafeteria, the communications center, medical office, some light industrial and shop areas, and an 800 seat auditorium.

The Wilson Hall Safety Improvements Project is a comprehensive project to remediate the deficiencies in this facility. Among the causes for the deficiencies are the age of the building and its systems, safety issues and updating to current code standards, and building components and systems that have reached their useful life expectancy.

The structural deficiencies are currently resulting in the ongoing safety issue of falling concrete debris in occupied areas of the building, and will eventually threaten the integrity of the entire facility. Additional spalling of the concrete could occur on the exterior faces of the building. The current glazing in the sloped window walls is not the code required safety glass. Breakage could result in the falling of sharp edged shards of glass into the atrium area. The quality of the existing drinking water is poor (taste & color) resulting in low usage which allows levels of lead and copper to exceed regulatory requirements.

The building structure portion of this project provides for the rehabilitation of the existing concrete structure at the crossover bays, which connect the two towers that comprise Wilson Hall. The joints between the crossover bays and tower are experiencing significant structural degradation, resulting in the ongoing safety issue of falling debris and the probability of continued deterioration of the joints. Recent computer analysis of the movement of the building structure has indicated that the joints need to be reworked to allow for the seasonal movement caused by temperature changes. This project will implement the solution to the joint erosion problem. It will consist of reconstructing the joints (assuring effective independent movement of each tower). Since a number of areas in the building will have restricted occupancy while the repairs are being made, this project will include the staff relocation required to accommodate the construction as part of Other Project Costs. At the completion of the structural joint repairs, a thorough exterior inspection will be conducted and any necessary repairs completed.

The building envelope portion of this project provides for the weatherproofing of components of the building shell that are currently allowing water penetration, the refurbishment of the existing skylight system, refinishing and partially reglazing the north and south curtain walls, and replacing the exterior entrances, including the entrance plaza:

Entry Plaza: The plaza that covers the "catacomb" area will have clear sealer applied to the sloped portions of the concrete walls enclosing the catacombs. The raised plaza portions will have waterproofing and pavers installed over the existing concrete. The existing paving at the entrance plaza will be removed and a new waterproof membrane and new paving will be installed.

North and South Curtain Wall: The north and south curtain walls of Wilson Hall are comprised of an anodized aluminum framing system that extends the full height of the building. The lower six floors of the system are sloped but do not have the current code required safety glazing. The finish of the aluminum framing is deteriorating and the system is allowing water penetration into the building. Safety glazing will be installed and the system will be repaired to resolve the water penetration.

4. Details of Cost Estimate [a]

(dollars in thousands)	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	920	920
Project Management costs (0.0% of TEC)	100	100
Total, Engineering design inspection and administration of construction costs (6.5% of TEC)	1,020	1,020
Construction Phase		
Buildings	8,850	8,850
Inspection, design and project liaison, testing, checkout and acceptance	870	870
Construction Management (11.7% of TEC)	1,820	1,820
Project Management (2.8% of TEC)	430	430
Total, Construction Costs	11,970	11,970
Contingencies		
Design Phase (1.1% of TEC)	170	170
Construction Phase (15.6% of TEC)	2,440	2,440
Total, Contingencies (16.7% of TEC)	2,610	2,610
Total, Line Item Cost (TEC)	15,600	15,600

5. Method of Performance

Overall project management, quality assurance, supervision of design and construction efforts and coordination with the U.S. Department of Energy for this project will be the responsibility of the Fermi National Accelerator Laboratory, through the Facilities Engineering Services Section (FESS). Design will be accomplished by a combination of FESS staff and consultant A/E fixed price contracts under the direction of the Facilities Engineering Services Section. Construction for project completion will be accomplished by means of one or more competitively bid, fixed price construction subcontracts. Construction Management and overall project management during the construction phase of this project will remain the responsibility of the Facilities Engineering Services Section of the Fermi National Accelerator Laboratory.

[a] The economic escalation rates from FY 1997 dollars for FY 1999 through FY 2001 are 5.3%, 2.9%, and 2.9% respectively from the Department Price Change Index FY 1999 Guidance, General Construction.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1998	FY 1999	FY 2000	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC	0	0	1,690	6,340	7,570	15,600
Other Project Costs						
Conceptual design cost	530	270	0	0	0	800
Other project-related costs[a]	0	0	560	380	1,460	2,400
Total, Other Project Costs	530	270	560	380	1,460	3,200
Total Project Cost (TPC)	530	270	2,250	6,720	9,030	18,800

7. Related Annual Funding Requirements

	Current Estimate	Previous Estimate
Wilson Hall related annual costs	NA	NA
Incremental utility costs (estimate based on FY 1997 rate structure)	NA	NA
Total related annual funding *(operating from FY 2003 through FY 2007)*[b]	NA	NA

[a] Includes funding for relocation of tenants before and after the construction and rebuilding of their workspaces; refurbishment of existing elevators which will be used for construction purposes, and then restored to public use.

[b] No incremental annual operating costs will result from the completion of this project.

00-G-307, Research Office Building, Stanford Linear Accelerator Center, Stanford, California

(Changes from FY 1999 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 2000 Budget Request	1Q '00	3Q '00	4Q '00	4Q '01	7,200	7,430

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
2000	2,000	2,000	950
2001	5,200	5,200	6,250

3. Project Description, Justification and Scope

The new Central Office Building project will construct a two-story building with approximately 30,000 gross square feet that will provide permanent, energy efficient office and conference space to meet the needs of the Laboratory. The office building will be located immediately adjacent to and north of the existing SLAC Administrative and Engineering building in the central campus area of the Laboratory. The new government-owned facility described herein will be located on leased land. Features include fixed and flexible office areas, meeting rooms and conference facilities equipped with interior office furnishings. Conventional utilities, such as domestic water, sanitary sewer, HVAC, and electrical power, will be provided by short connections from existing services. Specialized utilities include HVAC control and equipment, telecommunication for video and computers, and the main electrical feed. Construction of this building will allow the demolition of thirteen very old, temporary structures, totaling approximately 20,000 square feet.

This building will provide adequate facilities for the BaBar experimental program. This experimental program is critical to delivering the scientific understanding necessary to the success of the DOE's and the Nation's long-term science objective of maintaining the U.S. high energy physics program at the forefront of basics research.

With the increasing level of activity associated with the BaBar collaboration and SLAC's on-going high energy physics (HEP) experimental program, SLAC's space requirements are projected to exceed the capacity of currently existing office and meeting facilities. The BaBar experiment, which is scheduled to begin operation in FY 1999, expects a large influx of Users who will require adequate office and support space. SLAC expects to host approximately 1,100 HEP Users per year when the BaBar experiment begins full scale operations. The BaBar collaboration itself, consists of over six hundred users from around the world representing over seventy institutions. Office and meeting space is urgently needed to meet the demand created by this mega-collaboration. In the past, SLAC has only had about 200 collaborators/users in residence at any one time. Even at this level, most are housed in less than adequate facilities (the User community has become even more vocal about this in the past year or two). In the BaBar era, SLAC expects substantially more Users to be in residence and, as a national user facility, SLAC needs to be in a position to provide adequate space for them.

SLAC has investigated leasing and conversion alternatives to meet the projected need for office space but none has been judged to be as cost effective or satisfactory as the addition of the new office building. It was determined that there was insufficient off-site office space available nearby for leasing (12,000 square feet with a rental cost of $1,000,000 per year was available). Conversion of existing temporary and permanent facilities is not cost effective because the cost of renovation, necessary seismic and ADA work is roughly equal to the cost of new construction and the resulting space is inferior to new space specifically designed for office use. Additionally, valuable industrial space would be lost.

The use of substandard facilities could meet approximately two-thirds of this projected need but at substantial cost for necessary remedial work. With improved operating and energy efficiencies, it is estimated that the annual operating costs for this 30,000 square foot building will be equal to the current operating costs of the 20,000 square feet of temporary space to be removed.

If the new Central Office Building is not constructed, operating efficiencies and cost savings cannot be achieved, existing temporary structures, which are maintenance intensive and energy inefficient cannot be eliminated, the cost of seismic and ADA retrofitting will not be avoided, and parking will continue to be an operational deficiency in the main Computer Center area. Vehicular and pedestrian safety will not be improved. Commitments made to Stanford University and the SLAC HEP User population will not be met. An estimated $2,000,000 of avoidable costs will be incurred.

Funding is requested to initiate Preliminary and Final Design (Title I and II) of the project, procuring an Architect/Engineering firm to develop and oversee design, procure equipment, and begin construction.

4. Details of Cost Estimate [a]

	(dollars in thousands) Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs (5.8% of total estimated cost (TEC))	419	NA
Design Management costs at 23% of Preliminary and Final Design	98	NA
Project Management costs at 23% of Preliminary and Final Design	98	NA
Total, Design Phase	615	NA
Construction Phase		
Building	4,727	NA
Specialized Utilities	519	NA
Standard Equipment	496	NA
Construction Management at 2% of above	113	NA
Project Management at 1.5% of above	85	NA
Total, Construction Costs	5,940	NA
Contingencies at approximately 10 percent of above costs		
Design Phase (0.8% of TEC)	61	NA
Construction Phase (8.1% of TEC)	584	NA
Total, Contingencies	645	NA
Total, line item costs	7,200	NA

5. Method of Performance

Construction and procurement shall be accomplished by fixed price subcontracts on the basis of competitive bidding. Design and inspection shall be performed by the laboratory and contracted Architect-Engineers.

[a] Escalated to mid-point of construction with a factor of 1.0611. Allocated Indirects included in costs.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1998	FY 1999	FY 2000	Outyears	Total
Project Cost						
Facility Cost						
Design	0	0	0	615	0	615
Construction	0	0	0	335	6,250	6,585
Total Facility Costs (TEC)	0	0	0	950	6,250	7,200
Other Project Costs						
Conceptual design cost	0	0	30	0	0	30
Other project related costs [a]	0	0	0	0	200	200
Total, Other Project Costs	0	0	30	0	200	230
Total Project Cost (TPC)	0	0	30	950	6,450	7,430

7. Related Annual Funding Requirements

(FY 1998 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility maintenance/repair costs [b]	34	NA
Incremental utility costs [c]	36	NA
Total related annual funding	70	NA
Total Operating costs (operating from FY 2003 through FY 2007)	350	NA

[a] Includes funding for demolition of temporary structures; paving.

[b] Includes costs for janitorial services.

[c] Includes incremental utility costs for electric power and water.

00-G-307, Research Office Building, Stanford Linear Accelerator Center, Stanford, California

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Nuclear Physics

Program Mission

The Nuclear Physics program of the Department of Energy (DOE) has the lead responsibility for Federal support of nuclear physics research and supports fundamental research activities under the mandate provided in Public Law 95-91 which established the Department. The primary mission of the program is to develop and support the basic research scientists and facilities, and to foster the technical and scientific activities needed to understand the structure and interactions of atomic nuclei, and to understand the fundamental forces and particles of nature as manifested in nuclear matter. Atomic nuclei can be described as a collection of nucleons (protons and neutrons), bound together by the mechanism of exchange of mesons, mainly pi mesons (pions). The research forefront in nuclear physics now includes incorporation of the quark substructure of the nucleon into the understanding of nuclear structure and of quark-antiquark pairs to form the mesons. Quarks, which are the most elementary building blocks of matter, are bound together in groups of three by the exchange of gluons to form the nucleons.

Attendant upon this core mission are responsibilities to enlarge and diversify the Nation's pool of technically trained talent and to facilitate transfer of technology and knowledge acquired to support the Nation's economic base. The program works in close coordination with the Nuclear Physics program at the National Science Foundation (NSF), and jointly with the NSF charters the Nuclear Science Advisory Committee to advise on setting scientific priorities.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

Understand the structure of atomic nuclei and the fundamental forces required to hold their constituents in place, based on a series of systematic experimental and theoretical scientific investigations.

Program Objectives

- Conduct a program of maximum effectiveness to provide new insights into the nature of energy and subatomic matter, based on evaluation by rigorous peer review.
- Conceive, develop, construct, and operate world class scientific accelerator facilities in a timely, and effective manner. In the execution of this responsibility, together with other Science organizations, act as the Nation's leader in developing standards and management techniques to optimize construction and operations of facilities in a cost effective, safe, and environmentally benign way.
- Leverage United States objectives by means of international cooperation through exchanges of scientists and participation in internationally cooperative projects.
- Continue the advanced education and training activities of young scientists to maintain the skills and conceptual underpinning of the Nation's broad array of nuclear related sciences and technologies.

Performance Measures

- Evaluate the scientific quality and appropriateness of the total DOE Nuclear Physics program to maintain the United States position as world leader in nuclear physics research. Evaluations will be based on rigorous peer reviews conducted by internationally recognized scientific experts. Maintain the highest quality research by taking appropriate corrective management actions based on results of the reviews.
- Determine the production trends of diverse, highly trained young scientists - an essential ingredient for the vitality of the nation's technological base-using the Nuclear Physics annual census of scientific personnel. Funding patterns of university grants will include consideration of the optimum production rate of scientists.
- Use the assistance of technical experts to monitor the performance in scope, costs and schedule of construction projects for world class nuclear physics facilities such as the Relativistic Heavy Ion Collider. Measure project performance against cost and schedule milestones contained in project plans. Working with the relevant DOE project manager and laboratory project management, identify and establish programmatic modifications needed to enable projects to meet schedules and costs.
- Review at least 80 percent of the research projects by appropriate peers and selected through a merit-based competitive process.
- Use peer reviews and user feedback to monitor the effectiveness of facility operations. Evaluate facility performance against objectives set in program guidance based on funding availability, and measure achieved beam hour availability against guidelines developed for the Scientific User Facility Initiative. Identify participation and contributions by foreign scientists at facilities, and obtain input from user's groups at facilities. Develop appropriate facility funding profiles so as to best provide overall beam availability for the Nuclear Physics program.
- Measure overall program against the scientific priorities recommended in the long range plans that are regularly provided by the DOE/NSF Nuclear Science Advisory Committee (NSAC). Obtain assessments from NSAC and other community forums on the overall direction of the DOE Nuclear Physics program and its coordination with the NSF Nuclear Physics program. Based on this feedback, programmatic changes will be made, where necessary, to assure the Nuclear Physics program is appropriately directed towards highest priority topics in the long range plan.
- Upgrades of scientific facilities will be managed to keep them on schedule and within cost.
- Nuclear Physics will begin the research program at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) in FY 2000.

Significant Accomplishments and Program Shifts

Medium Energy Nuclear Physics

- In FY 2000, operations of the MIT/Bates Linear Accelerator Center facility will be terminated and Decommissioning and Decontamination (D&D) activities will begin.

- All three experimental halls at the Thomas Jefferson National Accelerator Facility are now operational for research. Beams of widely differing energies and currents can be delivered simultaneously to each of the halls to meet the specific requirements of the experiments. The laboratory is now also able to deliver polarized beam to any of the experimental halls.

Heavy Ion Nuclear Physics

- The Relativistic Heavy Ion Collider (RHIC) construction project at Brookhaven National Laboratory (BNL) continues on scope and budget with a completion date of the third Quarter of FY 1999. Fabrication of RHIC detectors, including the additional experimental equipment recommended by NSAC for purposes of particle detection and data analysis, also proceeds on schedule.

  In FY 2000 RHIC initiates its first full year of Operations and its research program will begin with four experiments (STAR, PHENIX, BRAHMS and PHOBOS) involving over 900 researchers and students from 80 institutions and 15 countries. The BNL Tandem/AGS/Booster accelerator complex, which acts as the injector for RHIC, will terminate routine operations of its fixed-target heavy-ion research program.

Low Energy Nuclear Physics

- Construction of the US/Canadian Sudbury Neutrino Observatory (SNO) detector, which sits in a nickel mine 6,800 feet below the surface of the earth, was completed in FY 1998. A dedication of the laboratory was held in Sudbury, Ontario, on May 28, 1998, with Stephen Hawking as one of the speakers. The filling of the region around the detector with water, and the central part of the detector with "heavy water" (D_2O), is now underway and initial measurements using the detector have commenced early in calendar year 1999.

- Gammasphere was moved from the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory (LBNL) to the ATLAS facility at Argonne National Laboratory (ANL) in FY 1998. A research program at ATLAS was initiated which is focused on the study of the structure of nuclei far from stability utilizing Gammasphere coupled with the existing Fragment Mass Analyzer (FMA). It is now planned that Gammasphere will operate at ATLAS in FY 1999 and move back to the 88-inch Cyclotron in FY 2000.

- The Radioactive Ion Beam (RIB) facility at Oak Ridge National Laboratory (ORNL) successfully developed new beams in FY 1998 and has initiated a series of experiments directed at measuring cross sections important to astrophysics.

Nuclear Theory

- In FY 2000 the Nuclear Theory Institute at the University of Washington continues its activities as a premier international center for new initiatives and collaborations in nuclear theory research.

Scientific Facilities Utilization

The Nuclear Physics request includes $234,000,000 to maintain support of the Department's scientific user facilities. This funding will provide research time for thousands of scientists in universities, Federal agencies, and U.S. companies. It will also leverage both Federally and privately sponsored research consistent with the Administration's strategy for enhancing the U.S. National science investment.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $106,000 and $88,000 for estimated contractor security clearances in FY 1999 and FY 2000, respectively, within the decision unit.

Funding Profile

(dollars in thousands)

	FY 1998 Current Appropriation	FY 1999 Original Appropriation	FY 1999 Adjustments	FY 1999 Current Appropriation	FY 2000 Request
Nuclear Physics					
Medium Energy Nuclear Physics	113,400	118,698	-155	118,543	111,130
Heavy Ion Nuclear Physics	94,736	150,592	-185	150,407	181,810
Low Energy Nuclear Physics	31,872	33,360	-135	33,225	34,170
Nuclear Theory	15,330	15,830	-70	15,760	15,830
Subtotal, Nuclear Physics	255,338	318,480	-545	317,935	342,940
Construction	59,400	16,620	0	16,620	0
Subtotal, Nuclear Physics	314,738	335,100	-545	334,555	342,940
Use of Prior Year Balances	-971 [a]	-776 [a]	0	-776 [a]	0
General Reduction	0	-545	+545	0	0
Total, Nuclear Physics	313,767 [b]	333,779	0	333,779	342,940

Public Law Authorization:

Public Law 95-91, “Department of Energy Organization Act”

[a] Share of Science general reduction of use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $5,660,000 which has been transferred to the SBIR program and $340,000 which has been transferred to the STTR program.

Funding by Site

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	10,783	9,750	10,260	+510	+5.2%
Chicago Operations Office					
Argonne National Laboratory	16,845	16,045	17,485	+1,440	+9.0%
Brookhaven National Laboratory	110,851	115,900	135,549	+19,649	+16.9%
Total, Chicago Operations Office	127,696	131,945	153,034	+21,089	+16.0%
Idaho Operations Office					
Idaho National Engineering Laboratory	90	80	80	0	0.0%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	21,965	22,118	18,080	-4,038	-18.3%
Lawrence Livermore National Laboratory	845	660	950	+290	+43.9%
Stanford Linear Accelerator Center . . .	9	0	0	0	0.0%
Total, Oakland Operations Office	22,819	22,778	19,030	-3,748	-16.4%
Oak Ridge Operations Office					
Thomas Jefferson National Accelerator Facility	68,850	70,305	73,669	+3,364	+4.8%
Oak Ridge National Laboratory	16,215	15,017	16,665	+1,648	+11.0%
Oak Ridge Institute for Science & Education	719	565	820	+255	+45.1%
Total, Oak Ridge Operations Office	85,784	85,887	91,154	+5,267	+6.1%
All Other Sites [a]	67,566	84,115	69,382	-14,733	-17.5%
Subtotal, Nuclear Physics	314,738	334,555	342,940	+8,385	+2.5%
Use of Prior Year balances	-971 [b]	-776 [b]	0	+776 [b]	+100.0%
Total, Nuclear Physics	313,767	333,779	342,940	+9,161	+2.7%

[a] Funding provided to universities, industry, other federal agencies and other miscellaneous contractors.

[b] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

Site Description

Argonne National Laboratory (ANL)

Argonne National Laboratory (ANL) in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. At Argonne, the Nuclear Physics program supports: (1) the Heavy Ion group, which operates the ATLAS Heavy Ion accelerator as a national user facility, and carries out related research; (2) the Medium Energy group, which carries out a program of research at TJNAF, Fermilab, and DESY in Germany; also supported are activities leading to a “spin” physics program at RHIC; (3) R&D directed at a proposed Isotope Separator On-Line accelerator facility (ISOL); (4) the Nuclear Theory group which carries out theoretical calculations and investigations in subjects supporting the experimental research programs in Medium Energy and Heavy Ion physics; and (5) data compilation and evaluation activities as part of the national data program.

Brookhaven National Laboratory (BNL)

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. The major effort at BNL, supported by the Heavy Ion Program, is the new Relativistic Heavy Ion Collider (RHIC) which uses the entire Tandem/Booster and Alternating Gradient Synchrotron (AGS) as an injector. RHIC is a major new and unique international user facility. RHIC will search for the predicted “quark-gluon plasma,” a form of nuclear matter not previously observed. The Medium Energy group has been supported to carry out a program of hypernuclear physics and baryon resonance research using proton beams from the AGS. The Laser Electron Gamma Source (LEGS) group uses a unique polarized photon beam to carry out a program of photonuclear spin physics at the National Synchrotron Light Source (NSLS). The BNL Nuclear Theory group provides theoretical support and investigations primarily in the area of relativistic heavy ion physics. Low Energy support is provided for detector and chemical analysis development for the Sudbury Neutrino Observatory (SNO) and involvement in the SNO research program. BNL is also the central U.S. site for the American and international nuclear data and compilation effort. The National Nuclear Data Center is housed at BNL.

Idaho National Engineering & Environmental Laboratory (INEEL)

Idaho National Engineering and Environmental Laboratory is a Multiprogram Laboratory located on 572,000 acres in Idaho Falls, Idaho. At INEEL, a program of nuclear data and compilation is supported.

Lawrence Berkeley National Laboratory (LBNL)

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Lab is on a 200 acre site adjacent to the Berkeley campus of the University of California. At LBNL, the Nuclear Physics program supports: (1) operations and research at the 88-inch Cyclotron, a heavy ion accelerator which is run as a national user facility; (2) the Relativistic Nuclear Collisions group, with activities at CERN/SPS, BNL/AGS, and RHIC, where they have been major players in the development of the large STAR detector for the new RHIC facility; (3) the Low Energy group, which plays a major role in the construction and implementation of the Sudbury Neutrino Observatory (SNO) detector; (4) the Nuclear Theory group, which carries out a program with emphasis on theory of relativistic heavy ion physics; and (5) the Nuclear Data group whose activities support the National Nuclear Data Center at BNL.

Lawrence Livermore National Laboratory (LLNL)

Lawrence Livermore National Laboratory is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. Low Energy Research support is provided for the setup and use of the GENIE detector for a program of neutron research using LANSCE beams at Los Alamos National Laboratory. A nuclear data and compilation effort is supported at LLNL.

Los Alamos National Laboratory (LANL)

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. Nuclear Physics supports a broad program of research including: (1) the Liquid Scintillation Neutrino Detector (LSND) experiment which is searching for evidence of neutrino oscillations, and a program of neutron beam research investigating parity violation in nuclei; these activities utilize beams from the LANSCE proton accelerator; (2) a major effort to build components of the PHENIX detector for the new Relativistic Heavy Ion Collider (RHIC) at Brookhaven, as well as to carry out a program of heavy ion research; (3) research is supported to study the quark substructure of the nucleon in experiments at Fermilab, and to plan for the detectors and research for a “spin” physics program at RHIC which will utilize polarized proton beams; (4) the development of the Sudbury Neutrino Observatory (SNO) detector as well as involvement in the planned research program; (5) a broad program of theoretical research into a number of topics in nuclear physics; (6) Nuclear data and compilation activities as part of the national nuclear data program.

Oak Ridge Institute for Science and Education (ORISE)

Oak Ridge Institute for Science and Education is located on a 150 acre site in Oak Ridge, Tennessee. Nuclear Physics support is provided through ORISE for activities in support of the new Radioactive Ion Beam Facility (RIB) and its research program.

Oak Ridge National Laboratory (ORNL)

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The major effort at ORNL is the Low Energy program support for research and operations of the new Radioactive Ion Beam Facility (RIB), which is run as a national user facility. RIB allows a program of experimental research investigating a number of issues in astrophysics. Also supported is a heavy ion group which is involved in PHENIX detector development activities for RHIC and the development of the RHIC research program. The theoretical nuclear physics effort at ORNL emphasizes investigations of low energy nuclear structure. Nuclear data and compilation activities are also supported as part of the national nuclear data effort.

Stanford Linear Accelerator Center

Stanford Linear Accelerator Center (SLAC) is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. SLAC uses computational tools (i.e. simulations, interactive techniques, remote access to instrumentation for data collection and manipulation), in partnership with educational institutions, for teaching and learning science as it relates to the Office of Science's Nuclear Physics mission.

Thomas Jefferson National Accelerator Facility (TJNAF)

Thomas Jefferson National Accelerator Facility is a program-dedicated laboratory (Nuclear Physics) located on 273 acres in Newport News, Virginia. Major Medium Energy program support is provided for the operation and research program of TJNAF, a new and unique international user facility for the investigation of nuclear and nucleon structure based on the underlying quark substructure. Also supported is a nuclear theory group whose program of investigations support the experimental program of the laboratory. The Nuclear Physics program provides most of the support for this new single purpose laboratory.

All Other Sites

The Nuclear Physics program funds research at 83 colleges/universities located in 35 states. This line also includes funding of research awaiting distribution pending completion of peer review results.

Medium Energy Nuclear Physics

Mission Supporting Goals and Objectives

The Nuclear Physics Program supports the basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. The Medium Energy Nuclear Physics subprogram supports academic fundamental research, and facility operations and research at electron and proton accelerator facilities at the higher energies of interest to nuclear physics. In addition, the subprogram supports research at accelerators operated by other Department of Energy programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities. The research programs are ultimately aimed at achieving an understanding of the structure of the atomic nucleus in terms of the quarks and gluons, the objects which are believed to combine in different ways to make all the other sub-atomic particles. Just as important is the achievement of an understanding of the "strong force", one of only four forces in nature, and the one which holds the nucleus of the atom together. Research efforts include studies of the role of excited states of protons and neutrons in nuclear structure, investigations of the role of specific quarks in the structure of protons and neutrons, studies of the symmetries in the behavior of the laws of physics, investigations of how the properties of protons and neutrons change when imbedded in the nuclear medium, measurements with beams of electrons or protons whose "spins" have all been lined up in the same direction (polarizing the beams) to determine unique "structure functions", and studies of how particles interact with each other inside the nucleus. Two national accelerator facilities are operated entirely under the Medium Energy subprogram - the Thomas Jefferson National Accelerator Facility (TJNAF) in Newport News, Virginia, operated by the Southeastern Universities Research Association and the Bates Linear Accelerator Center in Middleton, Massachusetts, operated by the Massachusetts Institute of Technology. These accelerator facilities serve a nationwide community of Department of Energy and National Science Foundation supported scientists from over 100 American institutions, of which over 90% are universities. Both facilities provide major contributions to American education at all levels. At both TJNAF and Bates, the National Science Foundation (NSF) has made a major contribution to new experimental apparatus in support of the large number of NSF users. A significant number of foreign scientists collaborate in the research programs of both facilities. The planned research program at the new TJNAF, for example, involves 600 scientists from 17 foreign countries; 81 of these scientists are from Conseil Europeen pour la Recherche Nucleaire (CERN) member states. At TJNAF, foreign collaborators have also made major investments in experimental equipment. Nuclear Physics will provide opportunities for college faculty and students to spend time at DOE laboratories, to participate in world-class research projects. Faculty/Student Science Teams will visit our DOE Laboratories during the academic summer/semesters, be involved in conducting research, writing proposals, utilizing technology and pursuing technical or scientific careers. Primary goals of the Science Teams are to build long-term partnerships among DOE laboratories and provide faculty/students with a deeper understanding of DOE science associated needs for research and development. Funds will be provided to pay for faculty/student stipends, travel, housing and subsidize laboratory scientists' time for this activity ($973,000).

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
Research					
University Research	16,080	17,085	15,662	-1,423	-8.3%
National Laboratory Research	19,713	20,124	19,985	-139	-0.7%
Other Research	987	6,064	5,748	-316	-5.2%
Subtotal, Research	36,780	43,273	41,395	-1,878	-4.3%
Operations					
TJNAF Operations	62,720	64,170	67,235	+3,065	+4.8%
Bates Operations	13,550	10,800	2,500	-8,300	-76.9%
Other Operations	350	300	0	-300	-100.0%
Subtotal, Operations	76,620	75,270	69,735	-5,535	-7.4%
Total, Medium Energy Nuclear Physics	113,400	118,543	111,130	-7,413	-6.3%

Detailed Program Justification

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

Research

University Research

These activities comprise a broad program of research, and includes 40 grants at 32 universities in 17 states and the District of Columbia. These research efforts utilize not only each of the accelerator facilities supported under the Medium Energy program, but also use other U.S. and international accelerator laboratories. Included in "Bates Research" is the effort performed at the MIT/Bates Linear Accelerator Center by MIT scientists. "Other University Research" includes all other university-based efforts using many research facilities, including MIT activities which are not carried out at Bates.

- **Bates Research:** At the MIT/Bates accelerator, university researchers have been carrying out "symmetry violation" studies on the proton in the North Experimental Hall. Out-of-plane measurements are being carried out using new spectrometers in the South Experimental Hall on the proton, deuteron, and complex nuclei including measurements of the transition of the proton to its excited state.
  - In FY 1999, important measurements will be completed in a limited experimental program.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ In FY 2000, the Bates accelerator will terminate operations. Supported MIT scientists will transition to other research facilities.	2,900	4,600	1,500
■ **Other University Research:**			
▸ University scientists are collaborating on important ongoing and future experiments at TJNAF. In FY 2000 activities include studies of the charge structure of the neutron in Hall C, planned measurements of the electric form factor of the proton, and a series of planned studies of the excited states of the proton in Hall B. First parity-violation measurements to look for the "strange quark" content of the proton in Hall A are already underway.			
▸ A number of university groups are collaborating in experiments using the new out-of-plane spectrometers in the South Experimental Hall at the Bates Laboratory. In FY 2000 Bates will cease operations; MIT and other university scientists will transition to other research facilities. Part of the Bates research funds are being added to other university research to support this transition.			
▸ University scientists and National Laboratory collaborators will continue to carry out the HERMES experiment at the DESY laboratory in Hamburg, Germany. This experiment will measure what components of the proton or neutron determine the "spin" of these particles, an important and timely scientific issue. In FY 2000, HERMES will utilize a new Ring Imaging Cerenkov counter for particle identification.			
▸ A new underground neutrino detector in Arizona is beginning a search for neutrino oscillations using the Palo Verde nuclear power reactors as the source of neutrinos. If neutrino oscillations are observed, implying neutrinos have mass, there would be a major impact on our understanding of the laws of physics. In FY 2000, the program will be completing its data-taking phase, and analysis will be underway.	13,180	12,485	14,162
Total, University Research	16,080	17,085	15,662

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

National Laboratory Research

Included is: (1) the research supported at the Thomas Jefferson National Accelerator Facility, which houses the Nation's new and unique high intensity continuous wave electron accelerator and (2) research efforts at Argonne, Brookhaven, and Los Alamos National Laboratories. The National Laboratory groups carry out research at various world facilities as well as at their home institutions

- **TJNAF Research:**
  - Scientists at TJNAF, with support of the user community, have completed assembly of new experimental apparatus for Halls A, B, and C. All three experimental Halls are now operational. TJNAF scientists provide experimental support and operate the apparatus for safe and effective utilization by the user community. TJNAF scientists participate in the laboratory's research program, and collaborate in research at other facilities.
  - Eight experiments have been completed in Hall C. Experimental equipment in Hall A is complete and the experimental program is underway. Four experiments have completed data accumulation in Hall A. The complex large-acceptance spectrometer in Hall B has been completed and the research program is now underway. One experiment has been completed. In FY 2000, the experimental program will run routinely in all three Halls.
  - Capital equipment funding will be provided for assembling and installing polarized electron injector improvements for the accelerator. Capital equipment funds will be used to install ancillary equipment items such as polarized targets for experimental Halls A, B, and C spectrometer systems, complete a major upgrade of the data reduction system to handle massive amounts of raw data, and to continue fabrication of second generation experiments such as a spectrometer that is designed to investigate the strange quark content of the proton. 5,600 5,600 5,700

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **Other National Laboratory Research:**			
▸ Argonne National Laboratory scientists are pursuing research programs at TJNAF, at the DESY Laboratory in Germany, and have proposed measurements of the quark structure of the nucleon at the new Main Injector at Fermilab. The theme running through this entire effort is the search for a detailed understanding of the internal structure of the nucleon.			
▸ At Brookhaven National Laboratory, scientists at the Alternating Gradient Synchrotron have been working with university researchers on experiments to look at the behavior of strange quarks in nuclei, and other work has been investigating the spectroscopy of strongly interacting particles. These efforts involve large detectors which were recently moved from Los Alamos and the Stanford Linear Accelerator Center. In FY 2000, efforts involving analysis of data obtained in prior years will be supported. The AGS will be primarily utilized as an injector for the new Relativistic Heavy Ion Collider (RHIC).			
▸ Also at Brookhaven, Laser Electron Gamma Source (LEGS) scientists are developing a new spectrometer and polarized target for a new program of spin physics. This unique facility produces its high energy polarized "gammas" by back scattering laser light from the circulating electron beam at the National Synchrotron Light Source (NSLS). In FY 2000, the research program utilizing the new equipment, will be fully underway.			
▸ At Los Alamos National Laboratory, scientists and collaborators may continue to carry out highly interesting but controversial measurements in search of neutrino oscillations. If oscillations are found, then neutrinos would have mass, in disagreement with our present understanding of the laws of physics.			
▸ Los Alamos National Laboratory scientists and collaborators are also developing detectors for the Relativistic Heavy Ion Collider which will enable use of polarized protons and which builds upon an experiment to measure the quark structure of the proton at Fermilab. . .	14,113	14,524	14,285
Total, National Laboratory Research	19,713	20,124	19,985

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000

Other Research

- **SBIR/STTR:** Amounts shown are the estimated requirement for the continuation of the SBIR and STTR programs and other established obligations which the Medium Energy Nuclear Physics subprogram must meet.
  - In FY 1998 $4,165,000 and $340,000 were transferred to the SBIR and STTR programs, respectively. The FY 1999 and FY 2000 amounts are the estimated requirement for the continuation of the SBIR and STTR programs. . . . . .

	FY 1998	FY 1999	FY 2000
SBIR/STTR	987	6,064	5,748
Total, Research	36,780	43,273	41,395

Operations

TJNAF Operations

Included is the funding which supports: (1) operation of the Continuous Electron Beam Accelerator at the Thomas Jefferson National Accelerator Facility, and (2) major manpower, equipment, and staging support for the assembly and dismantling of complex experiments.

- **TJNAF Accelerator Operations:**
  - The accelerator is now capable of delivering beams of differing energies and currents simultaneously to the three experimental halls. Polarized beam capability is now also available and is being used for experiments.

	(hours of beam for research)		
	FY 1998	FY 1999	FY 2000
TJNAF	4,500	4,500	4,500

  - AIP funding will provide for polarized injector and beam handling components which enable simultaneous polarized beam capability with varied operating parameters in the three experimental halls. AIP funding also supports other additions and modifications to the accelerator facilities. GPP funding is provided for minor new construction and utility systems. 39,755 41,200 43,360

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **TJNAF Experimental Support:**			
▸ Support is provided for the scientific and technical manpower, materials, and services needed to integrate rapid assembly, modification, and disassembly of large and complex experiments for optimization of schedules. This includes the delivery or dismantling of cryogenic systems, electricity, water for cooling, radiation shielding, and special equipment for specific experiments.	22,965	22,970	23,875
Total, TJNAF Operations	62,720	64,170	67,235

Bates Operations

- Funding is provided to support accelerator operations at the MIT/Bates Linear Accelerator Center.
  - Bates operations will terminate in FY 2000. Funding is provided for Decommissioning and Decontamination activities.

	(hours of beam for research)		
	FY 1998	FY 1999	FY 2000
Bates	2,000	1,000	0

▸ Accelerator operations in FY 1998 provided beams for the research programs in the North and South Halls, for testing of internal continuous beams in the South Hall Ring, and for development of extracted continuous beams for delivery to the existing South Hall spectrometers.			
▸ AIP funding has supported additions and modifications to the accelerator facilities; GPP funding has provided for minor new construction and utility systems. No AIP/GPP will be provided in FY 2000.	13,550	10,800	2,500
Other Operations			
■ This category includes facility operations funding at other facilities when the importance of the science justifies the partial support of another research facility.			
▸ No operations support of other facilities is planned in FY 2000.	350	300	0
Total, Operations	76,620	75,270	69,735
Total, Medium Energy Nuclear Physics	113,400	118,543	111,130

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
Research	
■ **University Research**	
▸ Since Bates facility operations will be terminated in FY 2000, Bates research has been reduced allowing for completion of data analysis only. MIT scientists will transition to other nuclear physics facilities	-3,100
▸ Other university research is increased by the addition of part of the Bates research funds, since a number of the MIT scientists will transfer their research efforts to other facilities.	+1,677
Total, University Research	-1,423
■ **National Laboratory Research**	
▸ TJNAF research support is increased to maintain level of TJNAF scientists in experimental research.	+100
▸ Other National Laboratory research is slightly reduced	-239
Total, National Laboratory Research	-139
■ **Other Research**	
▸ Estimated SBIR/STTR obligations decrease slightly.	-316
Total Research	-1,878
Operations	
■ **TJNAF Operations**	
▸ Funding for the Thomas Jefferson National Accelerator Facility operations is increased to cover increased cost of experiments and cost of living increases.	+2,160
▸ TJNAF experimental support is increased to provide more effective and efficient experimental setup and disassembly to improve scientific output.	+905
Total, TJNAF Operations	+3,065
■ **Bates Operations**	
▸ The MIT/Bates Linear Accelerator Center will cease operations. All planned Capital Equipment, AIP, and GPP funding has been eliminated	-8,300
■ **Other Operations**	
▸ No operations support of other facilities is expected in FY 2000.	-300
Total, Operations	-5,535
Total Funding Change, Medium Energy Nuclear Physics	-7,413

Heavy Ion Nuclear Physics

Mission Supporting Goals and Objectives

The Heavy Ion Nuclear Physics subprogram supports research directed at understanding the properties of atomic nuclei and nuclear matter over the wide range of conditions created in nucleus-nucleus collisions. Using beams of accelerated heavy ions at low bombarding energies, research is focused on the study of the structure of nuclei which are only gently excited (cool nuclear matter), but taken to their limits of deformation and isotopic stability. With higher energy heavy-ion beams it is possible to study highly excited nuclei (warm nuclear matter) which, when sufficiently heated, are expected to vaporize in a process analogous to the liquid-gas phase transition of heated water. At relativistic bombarding energies the properties of hot**,** dense nuclear matter are studied with a goal of observing the deconfinement of normal matter into a form of matter, a quark-gluon plasma, which is believed to have existed in the early phase of the universe, a millionth of a second after the Big Bang.

Scientists and students at universities and national laboratories are funded to carry out this research on Department of Energy (DOE) supported facilities, as well as on National Science Foundation (NSF) and foreign supported accelerator facilities. The Heavy Ion Nuclear Physics subprogram supports and maintains accelerator facilities located at two universities (Texas A&M and Yale) and three National Laboratories (Argonne, Brookhaven and Berkeley) for these studies. The Relativistic Heavy Ion Collider (RHIC), under construction at Brookhaven National Laboratory since FY 1991, is scheduled to begin operations in the 4th Quarter of FY 1999, initiating a high-priority research program addressing fundamental questions about the nature of nuclear matter. In FY 2000 resources will be directed towards initiating RHIC's research program in its first full year of operation. All the National Laboratory facilities are utilized by DOE, NSF and foreign supported researchers whose experiments undergo peer review prior to approval for beam time. Capital Equipment funds are provided for detector systems, for data acquisition and analysis systems and for accelerator instrumentation for effective utilization of all the national accelerator facilities operated by this subprogram. Accelerator Improvement Project (AIP) funds are provided for additions, modifications, and improvements to the research accelerators and ancillary experimental facilities to maintain and improve the reliability and efficiency of operations, and to provide new experimental capabilities. The Heavy Ion Nuclear Physics subprogram also provides General Purpose Equipment (GPE) and General Plant Project (GPP) funds, for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems, for the Brookhaven National Laboratory (BNL) as part of Nuclear Physics' landlord responsibilities for this laboratory.

Performance Measures

- Nuclear Physics will begin the research program at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) in FY 2000.

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
Research					
University Research	17,197	16,685	16,965	+280	+1.7%
National Laboratory Research	35,178	38,425	33,450	-4,975	-12.9%
Other Research	86	2,505	2,808	+303	+12.1%
Subtotal, Research	52,461	57,615	53,223	-4,392	-7.6%
Operations					
RHIC Operations	25,520	74,800	106,100	+31,300	+41.8%
National Laboratory Facility Operations	10,805	12,542	13,127	+585	+4.7%
Other Operations	5,950	5,450	9,360	+3,910	+71.7%
Subtotal, Operations	42,275	92,792	128,587	+35,795	+38.6%
Total, Heavy Ion Nuclear Physics	94,736	150,407	181,810	+31,403	+20.9%

Detailed Program Justifications

(dollars in thousands)		
FY 1998	FY 1999	FY 2000

Research

University Research

Support is provided for the research of scientists and students from over 30 universities.

- Research using relativistic heavy ion beams, involving about two-thirds of the university scientists supported by the Heavy Ion program, is focused on the study of the production and properties of hot, dense nuclear matter with priorities on the initial experiments at RHIC where an entirely new regime of nuclear matter will become available for study for the first time. University researchers are involved in all aspects (construction, installation and operation) of the four detector systems (STAR, PHENIX, BRAHMS, and PHOBOS) at RHIC.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ Research using low energy heavy ion beams, involving about a third of the university scientists, is focused on the study of the structure of nuclei with priorities on studies of highly excited nuclear systems, properties of unstable nuclear systems near the limits where protons and neutrons become unbound and reactions involving unstable nuclei that are of particular importance in nuclear astrophysics. These studies utilize the Gammasphere and Fragment Mass Analyzer Detectors with beams from the ATLAS and 88-inch Cyclotron facilities and complementary studies using the smaller university facilities (Yale and Texas A&M) whose in-house research programs also include an emphasis on student training.	17,197	16,685	16,965

National Laboratory Research

Support is provided for the research programs of scientists at five National Laboratories (ANL, BNL, LBNL, LANL and ORNL).

■ **BNL RHIC Research:** Laboratory researchers at BNL play a major role in planning and carrying out the research on the four experiments (STAR, PHENIX, BRAHMS and PHOBOS) at RHIC and have major responsibilities for maintaining, improving and developing this instrumentation for use by the user community. Activities will be focused on initiating a research program in the first full year of RHIC operations. FY 2000 will be a critical year involving continued integration of many different subsystems in the four RHIC detectors to facilitate the beginning of studies of the expected new forms of nuclear matter that will be created in heavy ion collisions at RHIC. The priority for the capital equipment included in this funding is on additional experimental equipment for RHIC, (see Major Items of Equipment) which includes a start in FY 2000 of the Electromagnetic Calorimeter enhancement for STAR whose preliminary TEC is about $5 million. This has been recommended in a NSAC review as important to enhance the physics objectives of the RHIC program. Included are funds for computing for off-line analysis, and enhancements to the baseline STAR and PHENIX detectors that address new physics.	15,247	17,870	12,400

	FY 1998	FY 1999	FY 2000
■ **Other National Laboratory Research:** Laboratory researchers associated with accelerator facilities at ANL (ATLAS) and LBNL (88-inch Cyclotron) have major responsibilities for maintaining, improving and developing instrumentation for use by the user community at their facilities, as well as playing important roles in carrying out research that address the Program's priorities. Activities will be focused on studies of the properties of short-lived nuclei using specialized instrumentation, studies of nuclear structure with Gammasphere and R&D efforts for the proposed next generation Isotopic Separation On-Line (ISOL) facility for radioactive beams. Researchers at LANL, LBNL, and ORNL will utilize their laboratory competencies in undertaking R&D, management and construction responsibilities for major initiatives such as RHIC detectors (e.g., STAR and PHENIX) and play leadership roles in carrying out research utilizing them. Activities will be focused on initiating a research program in the first full year of RHIC operations. The priorities for capital equipment in this funding are for support for the ongoing research activities at the supported accelerator facilities.	19,931	20,555	21,050
Total, National Laboratory Research	35,178	38,425	33,450
Other Research			
■ Amounts shown are the estimated requirements for the continuation of the SBIR and STTR programs and other established obligations. In FY 1998 $695,000 was transferred to the SBIR program. The FY 1999 and FY 2000 amounts are the estimated requirement for the continuation of the SBIR and STTR programs.	86	2,505	2,808
Total, Heavy Ion Nuclear Physics Research	52,461	57,615	53,223

(dollars in thousands)

Operations

RHIC Operations

- The RHIC Project is scheduled to be completed in the 3rd Quarter with commissioning operations beginning in the 4th Quarter of FY 1999. RHIC will be a unique facility whose colliding relativistic heavy ion beams will permit exploration of hot, dense nuclear matter and recreate the transition from

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
quarks to nucleons which characterized the early evolution of the universe. Studies with colliding heavy ion beams will provide researchers with their first laboratory opportunity to explore this new regime of nuclear matter and nuclear interactions which up to now has only been studied theoretically.			
▸ **RHIC/AGS Accelerator Operations:** Support is provided for the operation, maintenance, improvement and enhancement of the RHIC accelerator complex. The RHIC complex includes the Tandem/AGS facility whose fixed-target heavy-ion research program will be terminated in FY 2000 and which will serve as the injector for RHIC. RHIC will begin its first full year of operations with a 33 week running schedule and the goal of 22 weeks (3,300 hours) for research and 11 weeks for accelerator studies. .	25,520	66,800	76,675

	(hours of beam for research)		
	FY 1998	FY 1999	FY 2000
AGS	672	0	0
RHIC	0	500	3,300

▸ **RHIC Experimental Support:** Support is provided for the operation, maintenance, improvement and enhancement of the RHIC experimental complex, including detectors, experimental halls, computing center and support for users. RHIC will initiate its research program in FY 2000 with four experimental detectors (STAR, PHENIX, BRAHMS and PHOBOS). Approximately 1,000 scientists and students from 81 institutions and 15 countries will participate in the research programs of these four experiments.	0	8,000	29,425
Total, RHIC Operations	25,520	74,800	106,100

National Laboratory Facility Operations

Support is provided for two National User Facilities: the ATLAS facility at ANL and the 88-inch Cyclotron facility at LBNL for studies of nuclear reactions, structure and fundamental interactions.

	FY 1998	FY 1999	FY 2000
	(dollars in thousands)		

- Support is provided for the operation, maintenance, improvement and enhancement of the ATLAS and 88-inch Cyclotron accelerator facilities. FY 2000 ATLAS and 88-inch operations funding (and beam hours shown below) reflect the move of the Gammasphere program back to the 88-inch Cyclotron and the continued development of radioactive beam capabilities at ATLAS. These facilities are planned to provide yearly hours of beam for research as indicated below. In FY 2000 each facility will carry out about 40 experiments conducted by about 270 researchers.

(hours of beam for research)	FY 1998	FY 1999	FY 2000
ATLAS	5,700	5,700	5,300
88-inch Cyclotron	4,500	4,500	5,500

	FY 1998	FY 1999	FY 2000
▸ Accelerator Improvement Project (AIP) funds and capital equipment are provided for the maintenance and upgrade of these facilities.	10,805	12,542	13,127

Other Operations

	FY 1998	FY 1999	FY 2000
■ **GPP/GPE:** GPP funding will be provided for minor new construction, other capital alterations and additions, and for buildings and utility systems at Brookhaven National Laboratory (BNL). Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities and in meeting its requirement for safe and reliable facilities operation. Since it is difficult to detail this type of project in advance, a continuing evaluation of requirements and priorities may result in additions, deletions, and changes in the currently planned projects. The total estimated cost of each project will not exceed $5,000,000. In addition, the program has landlord responsibility for providing general purpose equipment (GPE) at BNL.	5,950	5,450	9,360
Total, Operations	42,275	92,792	128,587
Total, Heavy Ion Nuclear Physics	94,736	150,407	181,810

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
Research	
■ **University Research**	
▸ FY 2000 funding for University Research provides for almost constant effort compared to FY 1999 for research and educational activities.	+280
■ **National Laboratory Research**	
▸ The $3,000,000 of FY 1999 funding provided for experimental support for RHIC detector and computer efforts is shifted in FY 2000 to RHIC Experimental Support Operations. The plans made early in the project to procure computing equipment just prior to operations to secure the most powerful and up-to-date system at the lowest cost, are on schedule. In FY 2000 about $2,500,000 of the capital equipment funding provided in FY 1999 for RHIC computing and experimental equipment projects which expand RHIC scientific capabilities are shifted to RHIC Experimental Support Operations. The buildup of scientific and technical support and infrastructure needed for the RHIC detectors when they become operational in FY 2000, was supported in research in the years preceding the start of RHIC operations. This manpower and infrastructure belongs in RHIC Experimental Support and Operations in FY 2000. FY 2000 operating funding for research at National Laboratories other than BNL is up about $500,000 when compared with FY 1999 and distributed with emphasis on enhanced support for R&D efforts directed towards issues relevant to the proposed ISOL facility for radioactive beams.	-4,975
■ **Other Research**	
▸ Estimated funding for SBIR and other obligations increases from FY 1999. . . .	+303
Total, Research	-4,392
Operations	
■ **RHIC Operations**	
▸ First full year of RHIC operations commences. FY 1999 RHIC Construction funds of $16,620,000 are redirected to Operations. Approximately $5,500,000 of funds provided in FY 1999 to BNL RHIC Research for experimental support activities in preparation of start of RHIC Operations are transferred in FY 2000 to RHIC Operations. The FY 2000 funding provides for an estimated 33 week running schedule	+31,300

	FY 2000 vs. FY 1999 ($000)
■ **National Laboratory Facility Operations**	
▸ In FY 2000 funding for operations of the 88-Inch Cyclotron facility is increased to provide more beam hours for Gammasphere after its arrival from ATLAS. ATLAS operation will be slightly less than the FY 1999 level of effort.	+585
■ **Other Operations**	
▸ With the beginning of RHIC operations the program assumes landlord responsibility for providing general plant projects (GPP) and general purpose equipment (GPE) at BNL and ceases these responsibilities at LBNL.	+3,910
Total, Operations	+35,795
Total Funding Change, Heavy Ion Nuclear Physics	+31,403

Low Energy Nuclear Physics

Mission Supporting Goals and Objectives

The Low Energy Nuclear Physics subprogram supports research directed at addressing issues in nuclear astrophysics, the understanding of the behavior of nucleons at the surface of the nucleus as well as the collective behavior of the entire ensemble of nucleons acting in concert; nuclear reaction mechanisms; and experimental tests of fundamental symmetries. Part of this work can often be accomplished without the use of accelerators. The study of neutrinos from the sun, whose rate of production is not understood, is an example. University-based research is an important feature of the Low Energy subprogram. Since most of the required facilities are relatively small, they are appropriate for siting on university campuses, where they provide unique opportunities for hands-on training of nuclear experimentalists who are so important to the future of this field. Many of these scientists, after obtaining their Ph.D.s, contribute to a wide variety of nuclear technology programs of interest to the DOE. Included in this subprogram are the activities of the National Nuclear Data Center and its support sites that are aimed at providing information services on critical nuclear data and have as a goal the compilation and dissemination of an accurate and complete nuclear data information base that is readily accessible and user oriented.

Funding Schedule

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
University Research	9,447	9,810	10,050	+240	+2.4%
National Laboratory Research	8,468	8,770	8,725	-45	-0.5%
Nuclear Data	5,096	4,900	5,000	+100	+2.0%
RIB Operations	8,840	8,630	9,250	+620	+7.2%
Other	21	1,115	1,145	+30	+2.7%
Total, Low Energy Nuclear Physics	31,872	33,225	34,170	+945	+2.8%

Detailed Program Justifications

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
University Research			
■ The three main components of research at universities in this subprogram are nuclear astrophysics, fundamental interactions in nuclei, and the structure of nuclei. The support level for this activity is determined by juxtaposing the peer review assessment of the worth and priority of the project with the researchers request for the number of graduate students, postdoctoral fellows, other staff and necessary items to complete the proposed work.			
■ Two university accelerators are supported in Low Energy: the University of Washington, Nuclear Physics Laboratory (NPL), and the Triangle Universities Nuclear Laboratory (TUNL) facility at Duke University. These small university facilities fit within the low energy program by providing a source of light ion and neutron physics beams. Long term measurements of a detailed nature are possible at these dedicated facilities and they are used to make measurements that address questions of a fundamental physics nature.			
■ University scientists perform research at on-site facilities, as user groups at National Laboratory facilities, and at the Sudbury Neutrino Observatory (SNO). These activities address fundamental issues essential to the long term goal of understanding the production and constituents of stars.	9,447	9,810	10,050
National Laboratory Research			
■ **Radioactive Ion Beam Facility Research:**			
▸ The RIB facility will focus mainly on nuclear astrophysics problems bearing on the creation of the elements and nuclear properties with extreme proton/neutron ratios.			
▸ Installation of the Daresbury Recoil Separator, a \$2,000,000 device contributed by the United Kingdom, allows separation of the products of nuclear reactions from particles a trillion times more intense, enabling the measurement of nuclear reactions that fuel the explosion of stars.			
▸ Capital equipment funds are provided to expand the list of available beam species.			

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
▸ There will be an increased level of effort dedicated to research and development leading to an advanced RIB facility.	5,313	4,615	5,400
■ **Other National Laboratory Research:**			
▸ In a major effort to study the processes that control our sun, the Sudbury Neutrino Observatory (SNO) was created. This observatory consists of a 40 foot diameter plastic (acrylic) vessel that holds 1,000 tons of heavy water that is the solar neutrino detector. The SNO laboratory is located 6,800 feet underground. The detector water fill will be completed in FY 1999 and data taking will start. The level of SNO support at the national laboratories is at a continuing level of effort that allows the systematic and efficient collection and analysis of data.			
▸ The research that follows after the completion of filling the tank will determine whether the observed dearth of solar neutrinos results from unexpected properties of the sun, or whether it results from a fundamental new property of neutrinos—namely that neutrinos produced in radioactive decay change their nature during the time it takes them to reach the earth from the sun.			
▸ Capital equipment funds were used to construct and transport special rare gas Helium-3 neutron counters (800m total length) to their underground storage in the ultra low cosmic ray background environment of the SNO mine. They are being stored for a period of time which is sufficient to allow decay to low levels of the radioactivity induced in the detectors by the above ground cosmic ray background.	3,155	4,155	3,325
Total, National Laboratory Research	8,468	8,770	8,725

Nuclear Data

- This is a service function of the Nuclear Physics program which collects, evaluates, stores, and disseminates nuclear information. Its single national and international center point is the United States National Nuclear Data Center (US-NNDC) at Brookhaven National Laboratory. The level of effort is at an ongoing level and was peer reviewed by a panel of experts that addressed the activity level.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ The NNDC uses a network of individual nuclear data professionals located in universities and at other national laboratories who assist in assessing data as well as developing new novel, user friendly electronic network capabilities.			
■ The U.S. Nuclear Data Network (USNDN), a collaboration of DOE supported nuclear data scientists, reports to and supports the NNDC in data evaluation and development of on-line access capabilities.			
■ After completion of a review, a new activity, jointly supported with the Nuclear Physics research community, was established in order to serve the nuclear astrophysics community. This will be a joint activity between the US-NNDC and a consortium of researchers and data scientists. This new project, whose level of activity was established by user demand and input, will be an ongoing activity of the Data program.	5,096	4,900	5,000

RIB Operations

- ■ The RIB facility is planned to provide beam hours for research as indicated below:

	(hours of beam for research)		
	FY 1998	FY 1999	FY 2000
RIB	2,200	2,400	2,400

■ Research at the Oak Ridge Electron Linear Accelerator (ORELA), which is also operated by RIB staff, is aimed at resolving discrepancies in the rate of production of primordial elements compared with theoretical predictions, such as models that predict the formation of heavy elements like carbon, nitrogen, and oxygen in the Big Bang.			
■ This technically difficult project, which couples the existing cyclotron and tandem accelerators, was fully operational in FY 1998, and now is operating with radioactive ion beams of arsenic and fluorine as well as beams of Nickel-56.	8,840	8,630	9,250

Other

- ■ Amounts shown are the estimated requirement for the continuation of the SBIR and STTR programs. The Lawrence and Fermi Awards which are funded under this line, provide annual monetary awards to honorees selected by the Department of Energy for their outstanding contributions to nuclear science.

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ **SBIR/STTR:** In FY 1998 $800,000 was transferred to the SBIR program. The FY 1999 and FY 2000 amounts are the estimated requirement for the continuation of the SBIR and STTR programs.	21	1,115	1,145
Total, Low Energy Nuclear Physics	31,872	33,225	34,170

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
■ **University Research**	
▸ Research associated with RIB experiments and nuclear astrophysics research activities will increase while SNO construction activities will be completed. . . .	+240
■ **National Laboratory Research**	
▸ Increased research in high priority nuclear astrophysics measurements will replace a diminished activity in solar neutrino research.	-45
■ **Nuclear Data**	
▸ Support will increase for activities to provide data and services on-line to replace data and services previously supplied in hard copy.	+100
■ **RIB Operations**	
▸ RIB operations will be maintained with a cost-of-living increase thereby providing a constant amount of beam time.	+620
■ **Other**	
▸ Estimated FY 2000 funds for SBIR increase compared to FY 1999.	+30
Total Funding Change, Low Energy Nuclear Physics	+945

Nuclear Theory

Mission Supporting Goals and Objectives

Theoretical Nuclear Physics is a program of fundamental scientific research that provides new insight into the observed behavior of atomic nuclei. From continuing interaction with experimentalists and experimental data, solvable mathematical models are developed which describe observed nuclear properties, and the predictions of the models are tested with further experiments. From this process evolves a deeper understanding of the nucleus. Traditionally, there are two generic types of nuclear models: (1) microscopic models where the nucleus is viewed as a system of interacting discrete protons and neutrons, and (2) collective models where the nucleus is treated as a drop of fluid. With the establishment of the Quantum Chromodynamics and the standard model, the ultimate goal of nuclear theory now is to understand nuclear models, and hence nuclei, in terms of quarks and gluons. An area of increasing interest recently is in nuclear astrophysics-topics such as supernova explosions, nucleosynthesis of the elements, and the properties of neutrinos from the sun.

The Nuclear Theory program supports all areas of nuclear physics, and is carried out at universities and National Laboratories. Some of the investigations depend crucially on access to forefront computing, and to the development of efficient algorithms to use these forefront devices. Components of the program are selected primarily on the basis of peer review by internationally recognized experts. A very significant component of the program is the Institute for Nuclear Theory (INT), where there is an ongoing series of special topic programs and workshops. The Institute is a seedbed for new collaborations, ideas, and directions in nuclear physics.

Significant progress has been made in the past year. Three examples of particular accomplishments in that period are: (1) University theorists made a significant step forward in our understanding of how and where the heavier elements observed in nature were originally produced, producing strong evidence that they were produced in neutron rich gas at the core of supernova explosions. (2) Theorists at universities and the national laboratories, in several collaborative efforts, have developed increasingly sophisticated models of the reactions between ultra relativistic heavy ions, such as will be produced in the soon to be operating Relativistic Heavy Ion Collider facility at the Brookhaven National Laboratory. In the past year, several new and potentially clear signals of the creation of the quark-gluon plasma in such collisions were suggested by these models. (3) Recently, national laboratory theorists have found, quite unexpectedly, that effects due to special relativity can explain a symmetry in the low lying states of nuclei that is observed in a large number of nuclei, but for which there was previously no satisfactory explanation.

The program is greatly enhanced through interactions with complementary programs overseas and those supported by the National Science Foundation. Many foreign theorists participate on advisory groups and as peer reviewers. There is large participation in the INT by researchers from Europe and Japan.

Funding Schedule

	(dollars in thousands)				
	FY 1998	FY 1999	FY 2000	$ Change	% Change
University Research	9,974	10,464	10,510	+46	+0.4%
National Laboratory Research	5,356	5,296	5,320	+24	+0.5%
Total, Nuclear Theory	15,330	15,760	15,830	+70	+0.4%

Detailed Program Justifications

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
University Research			
■ Research is conducted through individual grants to faculty at roughly 50 universities.			
■ The range of topics studied through these grants is broad, and each of the active areas of experimental nuclear physics is supported by at least some of the nuclear theory grants.			
■ The overall character of the research program evolves with time to reflect changes in the overall nuclear physics program through redirecting some individual programs, phasing out other programs and starting new programs.			
■ Almost 100 Ph.D. students are supported by the Theory program, the major source of new Ph.D.s in nuclear physics in this country.			
■ The level of effort in this activity has been essentially constant in recent years. The bulk of the funds provided are used for salary support for faculty, postdocs, and students doing thesis research. Thus, a constant level of effort depends on a cost-of-living increase.			
■ The number of nuclear theorists supported in this activity is consistent with the recommendations for manpower levels in the report of the DOE/NSF Nuclear Science Advisory Committee Subcommittee on Nuclear Theory-1988.	9,974	10,464	10,510
National Laboratory Research			
■ Through this activity, small groups of theoretical nuclear physicists are supported at 6 National Laboratories.			
■ The range of topics in these programs is broad, and each of the active areas of experimental nuclear physics is supported by at least some of these nuclear theory activities.			

	(dollars in thousands)		
	FY 1998	FY 1999	FY 2000
■ In all cases, the nuclear theory research at a given laboratory provides support to the experimental programs at the laboratory, or takes advantage of some unique facilities/programs at that laboratory.			
■ The larger size and diversity of the National Laboratory groups make them particularly good sites for the training of nuclear theory postdocs.			
■ The level of effort in this activity has been essentially constant in recent years. The bulk of the funds provided are used for salary support for staff. Thus, a constant level of effort depends on a cost-of-living increase.			
■ The number of nuclear theorists supported in this activity is consistent with the recommendations for manpower levels in the report of the DOE/NSF Nuclear Science Advisory Committee Subcommittee on Nuclear Theory-1988.	5,356	5,296	5,320
Total, Nuclear Theory	15,330	15,760	15,830

Explanation of Funding Changes from FY 1999 to FY 2000

	FY 2000 vs. FY 1999 ($000)
■ **University Research**	
▸ Continue program at slightly reduced level of effort, consistent with less than cost-of-living increase in funding.	+46
■ **National Laboratory Research**	
▸ Continue program at slightly reduced level of effort, consistent with less than cost-of-living increase in funding.	+24
Total Funding Change, Nuclear Theory	+70

Capital Operating Expense and Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1998	FY 1999	FY 2000	$ Change	% Change
General Plant Projects	4,610	4,000	5,655	+1,655	+41.4%
Accelerator Improvement Projects	4,200	4,900	3,900	-1,000	-20.4%
Capital Equipment	26,110	29,586	30,355	+769	+2.6%
Total, Capital Operating Expense	34,920	38,486	39,910	+1,424	+3.7%

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1998	FY 1999	FY 2000	Accept-ance Date
STAR Silicon Vertex Tracker	7,000	3,450	1,500	1,300	750	FY 2000
PHENIX Muon Arm Instrumentation	11,400	3,375	2,800	2,400	2,525	FY 2001
Analysis System for RHIC Detectors	7,900	775	2,000	3,600	1,525	FY 1999
BLAST Large Acceptance Detector	4,900	400	900	900	0	TBD
STAR EM Calorimeter	TBD [a]	0	0	0	1,800	FY 2002
Total, Major Items of Equipment		8,000	7,200	8,200	6,600	

[a] Preliminary TEC is estimated to be about $5 million.